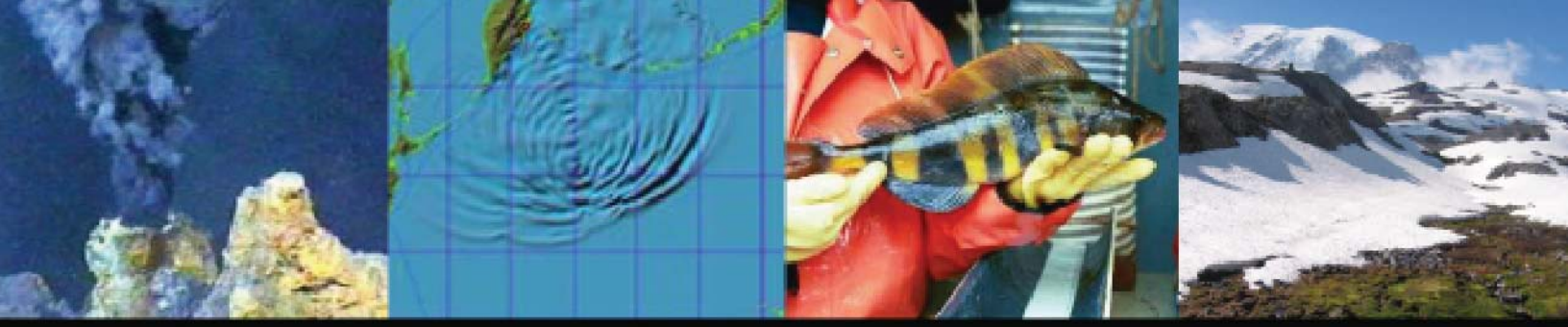

JOINT INSTITUTE FOR THE STUDY OF THE ATMOSPHERE & OCEAN (JISAO)

ANNUAL REPORT
July 1, 2004 – June 30, 2005

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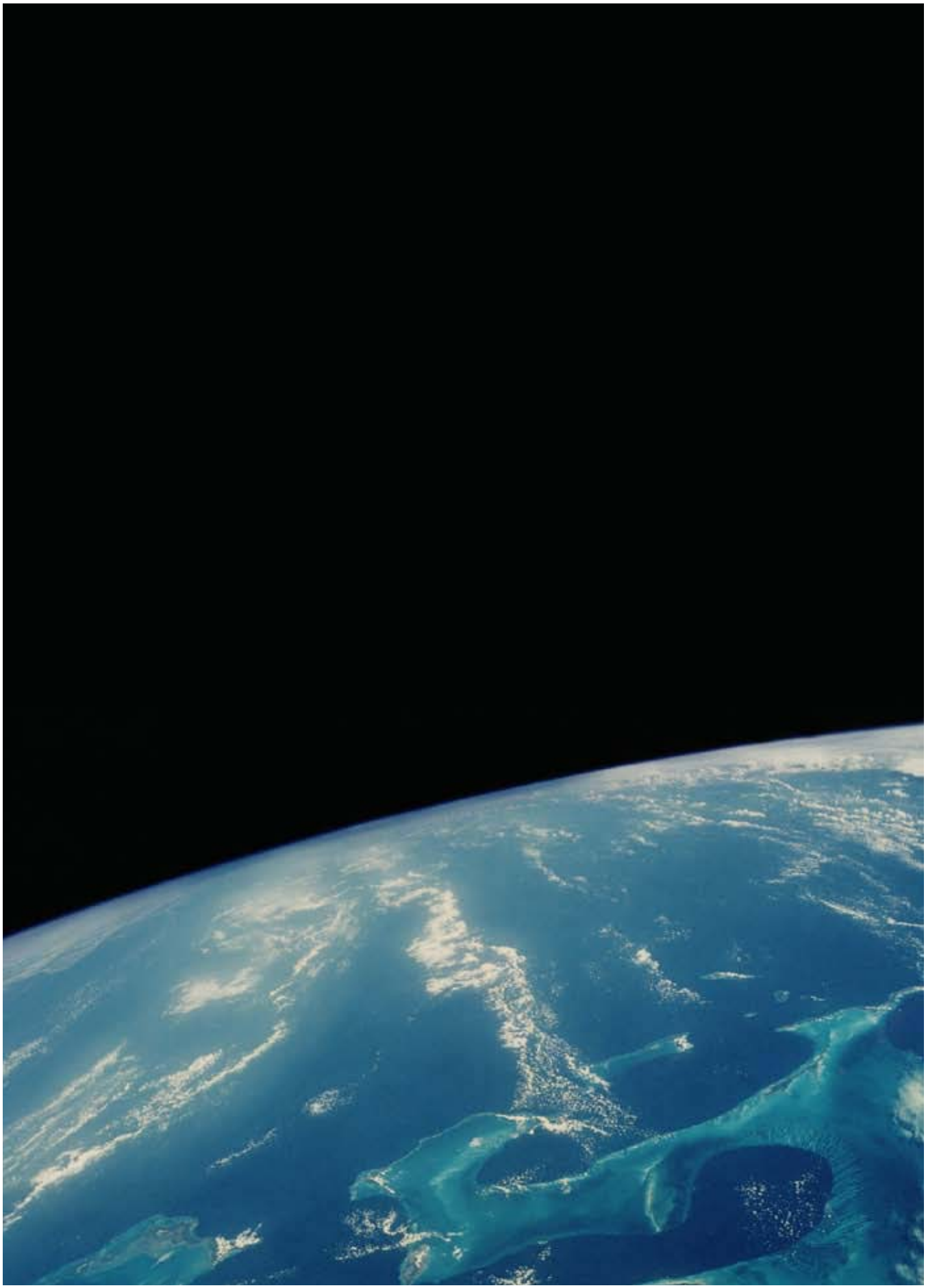

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EXECUTIVE SUMMARY

The Joint Institute for the Study of the Atmosphere and Ocean (JISAO) fosters collaborative research between the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington (UW) on a broad range of global and regional topics of concern to residents of this nation and, in particular, to local citizens of the Pacific Northwest by:

- ***enhancing*** research capabilities of UW and NOAA scientists, utilizing the diverse array of scientific and technical expertise and specialized research facilities within both institutions;
- ***facilitating*** the training of the next generation of NOAA's scientists by capitalizing on the UW's extraordinary strength in the geosciences and its degree granting authority;
- ***providing*** UW students the opportunity to participate in NOAA research, thereby enriching their educational experience; and,
- ***developing*** relationships with government agencies and industries in the state of Washington and throughout the Pacific Northwest, which assists NOAA in tailoring its climate forecasts and assessments to meet the needs of stakeholders.

As specified in JISAO's Memorandum of Understanding (MOU), the Institute is governed by a board of Senior Fellows who meet formally at least once per year and communicate more often when necessary via email and phone. As shown in Appendix 1, the members are divided evenly between University faculty and NOAA/PMEL personnel who hold affiliate faculty appointments. The Senior Fellows held all-day retreats on June 14, 2004 and June 22, 2005, to discuss policy and future directions.

JISAO's four major research themes, ***Fisheries Recruitment (Marine Ecosystems), Climate, Environmental Chemistry and Estuaries (Coastal Oceanography)***, encompass the wide range of mutual interests of NOAA scientists and UW faculty.

For internal programming purposes, two theme names have been changed: 'Fisheries Recruitment' to 'Marine Ecosystems' and 'Estuaries' to 'Coastal Oceanography'. In the remainder of this report, we will use the latter nomenclature. As described in the recent JISAO Review report, these relabeled themes are closely aligned with the goals of NOAA's Strategic Plan[1]. Each theme is broken down into the following focus areas:

MARINE ECOSYSTEMS

- Impact of climate variability on the Bering Sea and Gulf of Alaska marine ecosystems
- Linkages between physical, chemical and biological processes in the marine environment
- Spatiotemporal distributions, dynamics, and interactions of aquatic organisms
- Quantitative description of the distributions of aquatic organisms
- Distinguishing between climatic and human impacts on ecosystem dynamics
- Prediction of climatic and human impacts on ecosystem dynamics

CLIMATE

- Seasonal-to-interannual climate prediction
- Climate change in the Arctic
- Impacts of climatic variability and change on the Pacific Northwest

ENVIRONMENTAL CHEMISTRY

- The carbon cycle
- Aerosols and trace gases
- Hydrothermal vents

COASTAL OCEANOGRAPHY

- Tsunamis

[1] University of Washington, Joint Institute for the Study of the Atmosphere and Ocean (JISAO), 2005 NOAA/JISAO Review Binder, pp. 9-14, http://jisao.washington.edu/review2005/

Cutting across JISAO's four themes is a suite of activities, designated as Information Technology, that are designed to facilitate access to JISAO datasets and research results. Included in this category are websites and a set of web-based tools for accessing, managing, graphically representing, visualizing, and interactively exploring today's voluminous multi-dimensional datasets.

Research areas of growing emphasis in JISAO are tsunamis, climate impacts and Arctic climate change. Collaborations in marine ecosystems are also increasing, as evidenced in the number of projects in this area that were funded this year as a result of JISAO's continued efforts to foster closer relationships between NOAA's Alaska Fisheries Science Center (AFSC), Northwest Fisheries Science Center (NWFSC) and the UW School of Aquatic and Fishery Sciences.

JISAO's Cooperative Agreement research is funded through three tasks:

Task I, the Institute's "core program", also supported by the UW, includes:

- Two to three postdoctoral fellows on annual appointments, renewable for a second year.
- Senior visiting scientists on leave from their home institutions.
- Honoraria and travel expenses for short-term visitors.

JISAO provides space, computer access, administrative support, and other services for these individuals. Task I is also the vehicle for funding a percentage of the salaries for the JISAO administrator and one budget analyst, who manage and support the Institute's business and financial operations. Over the past year, Task I funding supported three postdocs (Taka Ito, Meredith Hastings and Andrew Rice) and the short-term visitors and activities listed in Appendix 2.

Task II serves as a vehicle for funding research scientists (UW professional staff), postdoctoral research associates and graduate students through the JISAO Cooperative Agreement grant. The Task II program supports directed, collaborative research efforts between NOAA and university scientists.

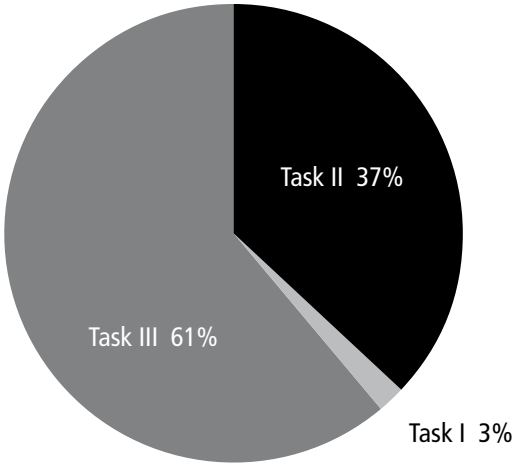
Task II funding supported a total of 76 professional staff housed at NOAA/PMEL (see Appendix 3). It also supported postdocs, Carlos Alvarez-Flores, Lorenzo Ciannelli, Yong Woo Lee, Franz Mueter and Regina Rodrigues, who are housed at PMEL and the Alaska Fisheries Science Center.

Task III supports University of Washington research in areas compatible with the Institute's major research themes. Along with Task II, Task III programs serve as vehicles for funding research scientists (UW faculty and professional staff), post-doctoral research associates and graduate students through the JISAO Cooperative Agreement grant.

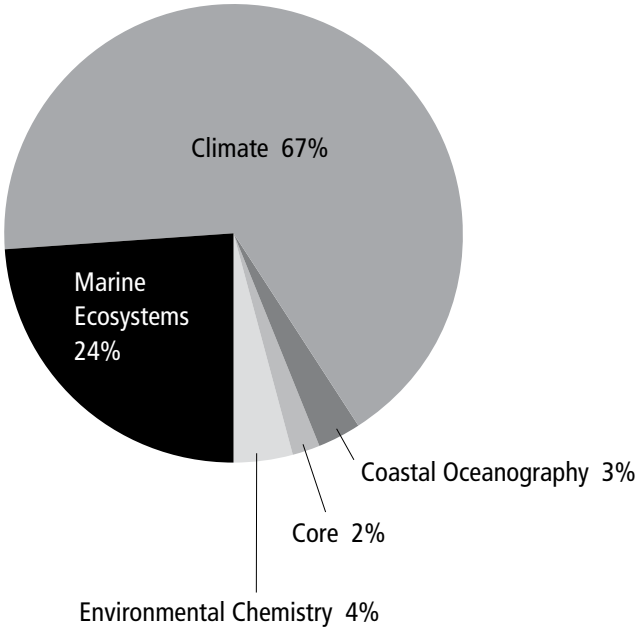
Task III supported postdocs, Jennifer Boldt, Jesús Jurado-Molina and Carolina Parada-Veliz. University of Washington grants and principal investigators on NOAA grants funded through Task III are listed in Appendix 4.

The JISAO/NOAA Cooperative Agreement funding for the four years ending on June 30, 2005 totals $46,972,954. JISAO's funding exclusive of the Cooperative Agreement for the same period amounts to another $5.3 million. The charts below break down Cooperative Agreement funding by task and theme for 20004-05:

TOTAL FUNDING BY TASK



TOTAL FUNDING BY THEME



JISAO partners with many organizations for both financial support and research collaborations. Below is a list of NOAA and UW offices involved with JISAO's programs:

NOAA:

Office of Atmospheric and Oceanic Research

- Arctic Research Office
- Climate Dynamics & Experimental Predictions
- Climate Observation and Services Program
- Office of Global Programs
- Pacific Marine Environmental Laboratory

National Marine Fisheries Service

- Alaska Fisheries Science Center
- Northwest Fisheries Science Center

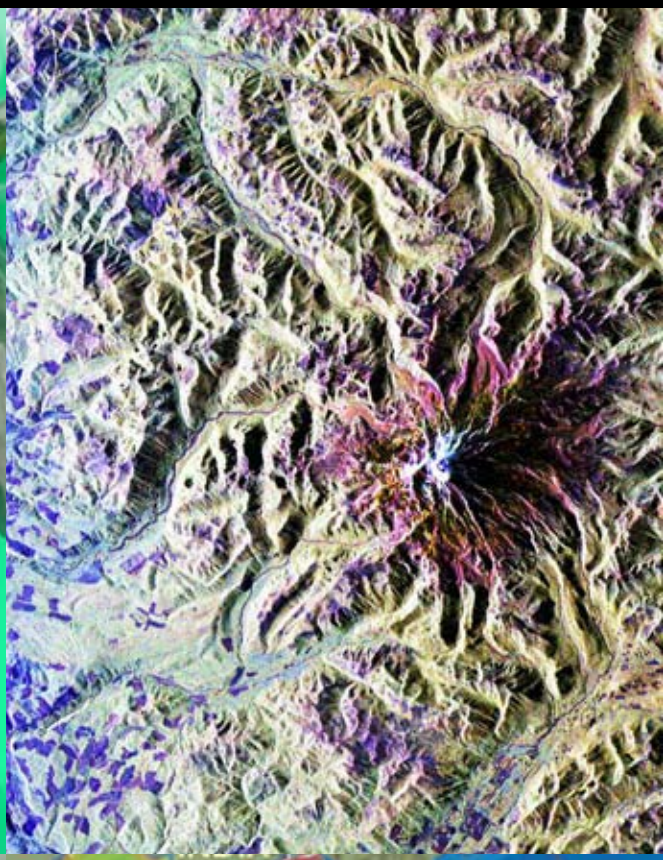
National Center for Tsunami Research

National Weather Service

UW:

- Center for Science in the Earth System
- College of Arts and Sciences:
  - Department of Earth and Space Sciences
  - Department of Atmospheric Sciences
- College of Engineering:
  - Department of Civil and Environmental Engineering
- College of Ocean and Fishery Sciences:
  - School of Aquatic and Fishery Sciences
  - School of Oceanography
  - School of Marine Affairs
  - Applied Physics Laboratory (APL)
- Evans School of Public Affairs
- Office of Research
- Program on Climate Change

RESEARCH HIGHLIGHTS



Detailed information about JISAO projects is found at the 'Research' link on JISAO's main website at http://jisao.washington.edu/research.html and at the individual websites of each project shown below.

Marine Ecosystems

http://www.pmel.noaa.gov/foci/
http://www.beringclimate.noaa.gov/

- Analyzed the Columbia River Chinook salmon baseline for its ability to differentiate between salmon populations. Four major groupings were identified that could be distinguished with approximately 95% accuracy.
- Participated in the standardization of microsatellite analysis between nine federal, state and university laboratories collecting data on Chinook salmon coastwide. The JISAO/PMEL laboratory scored highest out of all of the participating labs.
- Collected genotype data at 8 loci for 9 Chinook salmon populations (48 individuals each) to add to the existing Columbia River genetic baseline.
- Typed 240 individual salmon of unknown origin for the same 8 loci and determined their population-of-origin. Differential habitat usage by different salmon life history types was inferred.
- Developed ten Single Nucleotide Polymorphism (SNP) assays for chum salmon; 8 SNP assays for Chinook salmon.
- Genotyped 1000 bone samples for 8 loci to identify minimum number of individual salmon present in a single harbor seal scat sample.
- Analyzed the spatial and temporal variations in groundfish stocks from the U.S. west coast to the Bering Sea.
- Analyzed food habits of 20,707 groundfish in the laboratory and at sea.
- Collected one of the most geographically extensive datasets of Atka mackerel food habits.
- Evaluated a variety of statistical methods for predicting interannual variations in recruitment of different fish stocks.
- Developed the capability to monitor nitrate concentrations routinely and reliably from moored buoys.
- Improved a numerical model of the ocean circulation to better account for freshwater input along the coast of the Gulf of Alaska.
- Developed graphics and an interactive website for making ecosystem indicators and model results more useful and available to the public.
- Performed substantial model testing and evaluation on multispecies and ecosystem models of the Bering Sea and Aleutian Islands.

Climate

http://www.cses.washington.edu/ http://www.pmel.noaa.gov/tao/
http://tmap.pmel.noaa.gov/ http://www.arctic.noaa.gov/index.shtml
http://www.arctic.noaa.gov/detect/ http://psc.apl.washington.edu/search/
http://iabp.apl.washington.edu/

- Established mooring stations in the tropical Indian Ocean as part of an international effort to develop a sustained ocean observing system for climate in the region.
- Documented a decadal time scale intensification of the tropical Pacific Ocean circulation since the late 1990s in association with the Pacific Decadal Oscillation and this intensification was successfully modeled using a wind forced ocean general circulation model.
- Discovered significant intraseasonal (30-70 day) oscillation in tropical Atlantic surface winds, sea surface temperatures and surface fluxes linked to fluctuations in both the North Atlantic Oscillation and the Madden Julian Oscillation.
- Used TAO and related data sets to document the evolution of the weak 2004-05 El Niño.
- Documented the effects of local zonal wind stress forcing on ENSO time scale sea surface temperature variability in the eastern equatorial Pacific, showing that local wind stress variations during the 1982-83 and 1997-98 Niños accounted for about 1/3 of the maximum SST anomaly during those events.
- Noted, while researching trends in 20th century western snowpack, that the April 1 snow water equivalent (SWE) for much of North America declined significantly during the second half of the 20th century in a manner considered indicative of future losses due to climate change.
- Developed the scope, secured post-doc funding and hired a post-doc fellow for research on the role of climate variability in coastal Harmful Algal Blooms (HABs) events and predictability of HAB risks in the NE Pacific. This new effort is a collaboration between the JISAO Climate Impacts Group (CIG) and NOAA's new Center for Excellence in Oceans and Human Health at the Northwest Fisheries Science Center.
- Implemented an automated spinoff of forecasting system methods in a ½ degree resolution for the entire continental US (CONUS). Provisionally named the *UW Experimental Surface Water Monitor*, the daily nowcast of hydrologic conditions has become an operational hydrologic/drought monitoring system in its own right, and is consulted regularly by authors of the US Drought Outlook.
- Prepared forecast results for a Washington State emergency water group in connection with the regional drought.
- Continued regular, monthly real time hydrologic forecasts for the western US domain, augmented by bi-monthly updates in the Colorado River basin from January-April, and for the Pacific Northwest from March-May.
- Calibrated 30 new forecast points for the Colorado River basin were calibrated in collaboration with USDA National Resources Conservation Service, National Water and Climate Center (NWCC) forecaster, and 60 new points for the Missouri River basin (a forecast domain expansion) underwent development,
- Began research on examining scale issues for conducting a horizontal, integrated assessment of climate impacts in a Pacific Northwest coastal watershed.

Environmental Chemistry

http://www.pmel.noaa.gov/vents/home.html
http://saga.pmel.noaa.gov/
http://www.pmel.noaa.gov/co2/co2-home.html

- Expanded knowledge of unexplored areas of volcanic arcs and backarc basins of the western Pacific through participation in expeditions to Mariana arc, Kermadec arc, and Lau Basin.
- Collected a suite of hydrothermal fluid samples that surpasses all previous collections from volcanic arcs.
- Observed and sampled an actively erupting submarine volcano and venting of liquid CO_2.
- Continued to operate the world's first deep-sea observatory with two-way acoustic-satellite telemetry to the seafloor at Axial Volcano on the Juan de Fuca Ridge.
- Continued coordinated sampling for microbiology and chemistry of hydrothermal ecosystems and published results relating to the sub-seafloor biosphere.
- Quantified the output of CO_2 from hydrothermal systems through water column plume measurements and published results.
- Participated in the first research cruise by "telepresence" with broadband satellite connection to a research ship and submersible working 4500 miles away in the mid-Atlantic ocean.
- Collected unprecedented time-series samples for chemistry and microbiology as part of an integrated seafloor hydrothermal observatory on the Endeavour segment, Juan de Fuca ridge.

Coastal Oceanography

http://www.pmel.noaa.gov/tsunami/

- Demonstrated and interpreted the propagation patterns of the 26 December 2004 Sumatra Tsunami (Titov, et al. (2005a)), through model simulations and comparison with worldwide coastal tide gage data and with the satellite altimetry data.
- Presented verification of a Tsunami Forecasting methodology from the 17 November 2003 Rat Island Tsunami.
- Developed a tsunami forecast in near real-time that produced an extremely accurate match of the forecast and subsequent measurement of the tsunami time series at Hilo, Hawaii.
- Awarded a Gold Medal, the highest honor given by the Department of Commerce, for the development and successful transfer to operations of " … a new moored buoy system, developed by PMEL, to provide accurate and timely warning information for tsunamis." http://www.pmel.noaa.gov/tsunami/news_goldmedal.htm

Education and Outreach

JISAO scientists housed at PMEL and UW participate in teaching courses and in several educational outreach programs throughout the year, as described below. JISAO offers K-12 activities in collaboration with NOAA science camps and other programs, as well as with UW departments. The JISAO Climate Impacts Group (CIG) has an extensive outreach program described at http://www.cses.washington.edu/cig/outreach/outreach.shtml. Outreach to managers, planners, politicians and the public at large is a major part of the CIG mission. CIG also serves as a regular source for the media regarding the implications of global climate change (and global patterns of climate variability) for the Pacific Northwest (PNW).

JISAO scientists devote substantial time to briefing the media on research-related topics. In his role as state climatologist for the state of Washington, JISAO scientist, Philip Mote, devotes a substantial fraction of his time and effort to outreach. In recent months, the Tsunami Research Program has handled hundreds of interviews and media contacts regarding the tsunami research at PMEL. Along with PMEL scientists, the JISAO scientists involved are: Vasily Titov, Jean Newman, Angie Venturato, Diego Arcas, and Chris Chamberlin. More information is available at: http://www.pmel.noaa.gov/tsunami/.

Annually, JISAO provides the following educational and outreach activities, as well as some new events as listed below:

- Nathan Mantua and Amy Snover co-teach a UW graduate course titled "Climate Impacts on the Pacific Northwest". The class is cross listed with Atmospheric Sciences, School of Marine Affairs, Program on the Environment, and Earth and Space Sciences serving students from a wide range of natural and social science disciplines.
- Each year Professor Ed Miles, director of the Climate Impacts Group, teaches graduate courses dealing with climate impacts and climate policy in the UW School of Marine affairs, and JISAO scientist, Nicholas Bond teaches the laboratory section of a weather analysis and forecasting class offered by the UW Department of Atmospheric Sciences.
- Weekly seminars of the CIG are open to UW students
- Nearly half the JISAO senior fellows teach undergraduate science classes as a part of their responsibilities as UW faculty members. Some of these courses are for non-science majors.
- Many of the JISAO senior fellows participate actively in the UW Program on Climate Change (PCC). Several of the JISAO Senior Fellows from PMEL have given PCC seminars. Michael McPhaden, of NOAA/PMEL, gave this year's PCC Public Lecture.
- During the period of the current 5-year Cooperative Agreement, a total of 56 graduate research assistants have been funded for a portion of their time through JISAO. A list of these students, their academic departments, supervisors and degrees is provided in Appendix 8.
- Six JISAO scientists have had a major role in the design and staffing of a week-long science camp for middle-school students held at the NOAA Sandpoint campus. Last year, the camp served approximately 60+, 7th and 8th graders from a variety of schools in the Seattle area.

- Five JISAO scientists participated at PMEL in the annual "Bring Your Child to Work Day," by engaging 17 children, 9 years and older, in various activities related to PMEL research areas and physical/chemical oceanography.
- One JISAO employee, with four NOAA employees, participated in the annual Expanding Your Horizons Math, Science and Technology Conference for Girls which served 45 high schools girls who were interested in learning more about careers in oceanography.
- JISAO employees also participated in various lectures at schools, job shows, student tours of PMEL and similar individual outreach efforts. Several JISAO scientists participated in a 2-day workshop for science journalists in Seattle in November 2004.
- JISAO scientists serve on a wide array of advisory committees for the National Research Council, the federal government and various state and local agencies. For example, several JISAO senior fellows are involved in IPCC activities and the Tsunami Research Program works closely with state and local Emergency Management officials in Alaska, Washington, Oregon, California and Hawaii.

In conjunction with outreach efforts, JISAO is committed to recruiting students, faculty and staff from diverse backgrounds and cultures. Two staff members are currently working on developing and implementing a plan to attract women and underrepresented minorities to JISAO's programs.

JISAO Research Projects

MARINE ECOSYSTEMS

PROJECT:

Fisheries-Oceanography Coordinated Investigation (FOCI)

PI(S):
UW: N. Bond; NOAA: P. Stabeno

PERSONNEL:
UW: A. Hermann, Y. W. Lee, C. Mordy, F. Mueter, C. Parada, S. Rodionov
NOAA: J. Napp, S.A. Macklin, B. Megrey, J. Overland

TASK:
II & III

NOAA PRIMARY CONTACT:
National Marine Fisheries Service, Alaska Fisheries Science Center

NOAA GOALS:
1. Understand climate variability and change to enhance society's ability to plan and respond.

2. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

OBJECTIVES:

1. Improve and expand observational network necessary to monitor the ecosystem, verify models, and develop indices.
2. Improve understanding of the effects of climate variability on the North Pacific marine ecosystem.
3. Describe and quantify temporal variability in the spatial distribution of individual groundfish species and groundfish assemblages.
4. Relate variability in geographic distribution to environmental changes, changes in abundance, and fishing.
5. Assess the performance of the statistical tools currently used to forecast walleye pollock recruitment

ACCOMPLISHMENTS:

1. Recent advances have permitted a marked improvement in mooring instrumentation. Nitrate meters are now routinely deployed in the Gulf of Alaska and Bering Sea. These instruments have permitted the group to better understand the draw down and replenishment of nutrients over the Bering Sea shelf and the introduction of nutrients to the euphotic zone in the Aleutian Islands (Mordy et al. 2005). In addition, it has been possible (in collaboration with J. Resing) to modify available technology to measure iron (Fe) from moorings. The outer shelf of the Gulf of Alaska has long been hypothesized as being Fe limited, while the freshwater core of the Alaska Coastal Current was thought to be rich in Fe. Since Fe measurements on ships are difficult, the goal was to develop the ability to measure Fe on the mooring, using existing equipment,. Testing of this instrument will be carried out in August 2005.

   Capabilities of shipboard instruments continued to be expanded. Nitrate is now regularly measured in the sea chest on most of the cruises. These nitrate measurements, when combined with temperature, salinity and fluorescence data, provide insight into the spatial variability of near surface waters, their productivity and the relationship between primary production (as indicated by fluorescence) and nitrate draw down.

   Data from the moorings and from shipboard instruments have provided information to fine tune the nested physical and biological models that have been developed over the last several years by JISAO and NOAA personnel.

2. There has been continued progress in the development of conceptual and numerical models for the Bering Sea and Gulf of Alaska. The conceptual models are indicating key mechanisms regulating the marine ecosystem in various regions, and hence are informing the design and refinement of numerical models. The ocean

numerical models are being run with increasingly higher resolution, and with more realistic atmospheric forcing and boundary conditions. They are being coupled to biochemical models that include more explicit treatment of nutrients and lower-trophic level interactions. An important outcome of this work is the capability to begin examining the pathways through which the ecosystem is responding to the recent warming of the Bering Sea.

3. NMFS trawl survey data from the U.S. West Coast, Gulf of Alaska, Aleutian Islands, and Eastern Bering Sea was used to describe the spatial distribution of each taxon that was consistently identified across surveys ranging from 1975 to the present. (See detailed information of this project under, "Variability in the Spatial Distribution of Demersal Species along the West Coast of North America in Response to Climate Changes and Fishing.")

4. Analyses are underway to relate the observed changes in the distribution of individual taxa and groups of taxa to variability in water temperature, variability in absolute abundance (density-dependent effects), and to variability in overall fishing effort. (See detailed information of this project under, "Variability in the Spatial Distribution of Demersal Species along the West Coast of North America in Response to Climate Changes and Fishing.")

5. The accuracy of five different techniques for forecasting walleye pollock recruitment was evaluated in a controlled simulation setting. The most promising and robust statistical methods were applied to actual Gulf of Alaska walleye pollock spawning biomass, recruitment and environment data in order to provide information useful for fisheries managers.

PROJECT:

Biophysical Models of Pollock Recruitment Processes in the Western Gulf of Alaska

PI :
NOAA: S Hinckley

PERSONNEL:
UW: C. Parada. A. Hermann
NOAA: B. Megrey; UW & NOAA: J. Horne

TASK:
II

NOAA PRIMARY CONTACT:
Alaska Fisheries Science Center

NOAA GOALS:
1. Understand climate variability and change to enhance society's ability to plan and respond.

2. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management

OBJECTIVES:

The overall objective of this project was to implement a spatially-explicit biological model coupled to a hydrodynamic model, and to use the model to study spatial and temporal recruitment variability and early life history of walleye pollock *(Theragra chalcogramma)* in the western Gulf of Alaska. The suites of models are coupled also to a nutrient-phytoplankton-zooplankton model simulating the dynamics of pollock prey. These coupled models were used to:

1. Study the effects of the timing and location of spawning products in Shelikof Strait on pre-recruitment variability on a multi-year basis.
2. Study inter-annual variability of transport in the Shelikof region related to recruitment success.
3. Study the importance of the Shumagin Island as nursery area and alternatives regions such as the Semidi Islands.
4. Study the spatial and temporal synchronization between modelled *Pseudocalanus* production and early stages of pollock.
5. Compare annual recruitment variability of walleye pollock with pre-recruitment indices produced by the models.
6. Compare the spatial distribution of pollock produced by the models with the distribution of larvae and juveniles from surveys

ACCOMPLISHMENTS:

1. The spatial and temporal variability of the nursery grounds for walleye pollock, and the ability of the suite of coupled models to hindcast the recruitment variability were explored.
2. Model indices of abundance of age-0 juveniles of this stock that are two years ahead of entry of a year class into the fishery were developed and stock structure of pollock in the Gulf of Alaska was examined. A series of experiments was run using the coupled models.
3. Two types of larval and juvenile indices were extracted from the information provided by the pollock IBM, transport and distribution indices. The larval and juvenile transport indices were defined as the proportion of individuals in the each stage that arrive at the nursery area weighted by the residence time. The initial conditions of spawning in all experiments were particles released between 100-200 m in Shelikof Strait during the month of March. These particles were tracked all the way to the nursery areas. The indices of transport were calculated and compared with the juvenile age-2 assessments for the same period (1978-2002) using the Shumagin and Semidi Island regions as target nursery areas in the simulation experiments.

   These comparisons resulted in a poor correlation for both target areas. A high frequency of zero juvenile transport indices was observed for the Semidi Island region, indicating the need to

improve the behavior associated with juveniles in the IBM, since juveniles are found in these areas in the surveys. A better correlation was observed between larval transport index and Age-2 recruits during the late 70s to the middle 80s for the Semidi Is. (R^2=0.46) and Shumagin Is. (R^2=0.79).

The poor correlation between the modeled juvenile index and the age-2 assessment after mid-1980s may be explained by the lack of sources of mortality in the IBM. Inclusion of temporally and spatially explicit predation mortality into the IBM may significantly improve the correlation between the modeled juvenile index and the age-2 assessment numbers. The spatial distribution of larvae produced by the IBM (larval and juvenile distribution indices) resembles the data in some years, having a better representation on the 80´s. The spatial distribution of juvenile age-0's produced by the IBM by areas (Kodiak, Shelikof and Shumagin areas) showed agreement with the data for the 80´s. However, it was consistently seen, a further offshore distribution of age-0 juvenile in the IBM outputs compared with data from surveys.

Of the objectives, 2, 3,5 and 6 were completed. The first was not reached completely because the boundaries of the available hydrodynamic model output of region was constrained and it allowed the group to perform experiments only for the Shelikof Strait region, where the physical model was reliable. The fourth is currently in progress.

PROJECT:

Variability in the Spatial Distribution of Demersal Species along the West Coast of North America in Response to Climate Changes and Fishing

PI:
NOAA: J. Napp, B. Megrey,

PERSONNEL:
UW: Andre Punt, F. Mueter

TASK:
II

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center

NOAA GOALS:
1. Understand climate variability and change to enhance society's ability to plan and respond

2. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management

OBJECTIVES:

1. Describe and quantify temporal variability in the spatial distribution of individual groundfish species and groundfish assemblages
2. Relate variability in geographic distribution to environmental changes, changes in abundance, and fishing.

ACCOMPLISHMENTS:

1. The group used NMFS trawl survey data from the U.S. West Coast, Gulf of Alaska, Aleutian Islands, and Eastern Bering Sea to describe the spatial distribution of each taxon that was consistently identified across surveys ranging from 1975 to the present. The number of taxa analyzed in each region was 79 (47 fish taxa, 32 invertebrates) in the Bering Sea, 69 in the AI (39 fish, 30 inverts), 94 in the Gulf of Alaska (65 fish, 29 inverts), and 88 along the West Coast (71 fish, 17 inverts). The spatial distributions were examined along the two main gradients, the depth gradient and an alongshore-geographical gradient. The latter was used to describe distributions along the relatively narrow shelf off the west coast of North America, which includes a strong north-south component as well as a strong east-west component in the Gulf of Alaska. The spatial distributions was quantified by (1) estimating the center of distribution for each taxon and survey along these gradients (average depth of occurrence over the survey region, weighted by catch-per-unit-effort (CPUE); and average CPUE-weighted "alongshore distance") and (2) estimating linear gradients with depth and alongshore distance in CPUE (abundant species) or frequency of occurrence (rare species) by region. The group found significant differences in both the depth distribution and the alongshore distribution of numerous taxa over time. Some taxa showed large interannual variability but no clear trend, while several taxa showed clear trends over time in their average alongshore distribution and/or in their average depth distribution. The group is currently evaluating the proportion of taxa that appear to show a northward shift in distribution and the proportion of taxa that appear to show a shift towards greater depths over time.
2. Analyses are ongoing to relate the observed changes in the distribution of individual taxa and groups of taxa to variability in water temperature, variability in absolute abundance (density-dependent effects), and to variability in overall fishing effort. Bottom temperatures from trawl survey data were used to estimate average annual temperature anomalies across each region. Preliminary results suggest a strong coupling between bottom temperatures and the spatial distribution (with regard to both depth and alongshore distance) of mobile taxa and of overall demersal biomass. Abundances for each taxon by year were obtained from stock assessments for major commercial taxa or were directly estimated from the survey data. Preliminary results suggest that density has only weak effects on the spatial distribution of most taxa. Analyses of the effects of fishing on the distribution of individual taxa are in the beginning stages.

All objectives are scheduled for completion by December 2005.

PROJECT:

Forage Fishes in the Western Gulf of Alaska: Variation in Productivity

PI:
NOAA: M. Wilson

PERSONNEL:
UW: M. Mazur, D. Beauchamp

NOAA: A. Dougherty, A. Buchheister, C. Jump

TASK:
II

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

2.Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVES:

1. Investigate the influence of temperature and prey quality on the growth of juvenile walleye pollock.
2. Investigate the influence of the Alaska Costal Current on the growth of juvenile walleye Pollock.
3. Parameterize a bioenergetics model for capelin.

ACCOMPLISHMENTS:

1. A bioenergetics model for juvenile age-0 walleye pollock was evaluated for its utility in investigating the influence of spatially variable habitat conditions on the growth of juvenile walleye pollock. Similarities in independent estimates of prey consumption generated from the bioenergetics model and a gastric evacuation model corroborated the performance of the bioenergetics model. A mean squared error analysis (MSE) was also used to partition the sources of error between both model estimates of consumption into a mean component, slope component, and random component. Differences between estimates of daily consumption were largely due to differences in the means of estimates and random sources of error, and not differences in slopes. The lack of error associated with the slopes illustrated that the difference between estimates was consistent across the size range of pollock in this analysis. Similarly, the strong correlation of the consumption estimates indicates that the systematic error was small. Daily growth estimates generated from the bioenergetics model were within the range of growth estimates obtained from an otolith analysis of juvenile walleye pollock.

   Spatially explicit environmental influences on growth -- The bioenergetics model for juvenile walleye pollock was applied to a spatially distinct grid of samples in the western Gulf of Alaska to investigate the influence of temperature and prey quality on size-specific growth. Daily growth estimates for 50, 70, and 90-mm standard length walleye pollock during September 2000 were generated using the bioenergetics model with a fixed ration size. Temperature and prey quality was responsible for 66% of the observed variation between bioenergetics and otolith growth estimates across all sizes of juvenile pollock.

   Whole body energy content (WBEC) of key prey -- many applications of bioenergetics models, out of necessity, use literature values of whole body energy densities for prey and predators. However, the energy content of both predators and prey can vary spatially and temporally due to variable environmental conditions. Erroneous energy density values for some or all of the prey groups consumed by walleye pollock could lead to misinterpretations of the level of predator demand for specific prey or contribution of that prey group to the growth of the modeled fish. Measurements of the energy

content of prey groups found in the juvenile pollock diet were estimated using a Parr 1425® Semi-micro bomb calorimeter. WBEC estimates were then used to quantify the contribution of each prey group to the size-specific growth of juvenile pollock.

2. The bioenergetics model was used to investigate the hypothesis that forage-fish productivity is greater along the downstream margin of the Shelikof sea valley due to prey field enhancement associated with an influx of Alaska Coastal Current water (ACC). For juvenile walleye pollock, higher quality growth habitat was associated with ACC along the eastern edge of the Semidi bank and the near shore portion of the sample grid in 2000 and 2003. However, the highest growth areas during 2001 were located in the central Semidi bank region and were farther removed from the influx of ACC water. These results illustrate that growing conditions for juvenile walleye pollock in the western Gulf of Alaska vary both in distribution among years and across spatial scales of tens of km2.

3. The parameterization of the capelin model is ongoing. The model construction has been hampered by a lack of capelin specific physiological information in the scientific literature.

PROJECT:
Atka Mackerel Food Habit Project

PI:
UW: Timothy Essington

PERSONNEL:
UW: Kimberly Rand

TASK:
III

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

OBJECTIVES:

1. To better understand the ecological and oceanographic processes that give rise to geographic variation in Atka mackerel growth rates. Atka mackerel exhibit a pronounced east to west growth gradient, with the smallest-growing fish residing in the far western Aleutians and the fastest growing fish in the eastern Aleutians and western Gulf of Alaska. Because there is no evidence of stock differentiation, it was hypothesized that this gradient was the result of different environmental conditions, such as contrasts in food quantity or quality in the eastern regions.

   To that end, it is proposed to describe the food habits of Atka mackerel collected along this gradient in 2004, as well as use existing food habits data collected prior to this study. These specimens are unique in that they were collected in areas of high Atka mackerel abundance over several months (June through November) during day and night.

2. In addition to the above-described main objective, it is proposed also to initiate work on a second, related objective that seeks to better understand small-scale habitat utilization of Atka mackerel. This is motivated by observations of segregating spatial distributions of males and females during the spawning season, and recent shift of males into deeper waters. Small-scale spatial patterns in Atka mackerel food habits have not been examined nor have seasonal or sex-related patterns.

   This research will provide the small-scale temporal and spatial resolution of Atka mackerel food habits necessary to define essential fish habitat and its utilization for feeding. The results will be compared to the results of a parallel study on Atka mackerel reproductive ecology, thus providing an integrated examination of Atka mackerel habitat utilization.

ACCOMPLISHMENTS:

1. Examine stomach contents of Atka mackerel samples representing the greatest range of Aleutian habitat. Processing of these samples is ongoing. To date, laboratory analysis of approximately 2,100 Atka mackerel stomachs have been completed in the Alaska Fisheries Science Center, REEM (Resource Ecology Ecosystem Modeling) stomach lab. Species composition has been analyzed to standards set by the REEM lab. In addition to the processing of these samples, an additional 1,000 stomach samples were collected in '04 by Kim Rand. Ms. Rand acted as field party chief for this cruise. Ms. Rand is presently analyzing these samples in the lab, and all analyses are expected to be completed by October 2005.

2. Explore and document spatial, seasonal, and diel differences in food habits data.

   As processing of stomach samples is still ongoing, no data analyses have yet been conducted. A preliminary analysis of diet data collected in 1999 near Seguam Island in the Aleutian chain has revealed the importance of euphausids for Atka mackerel diets. There was little difference between sexes in food habits, but there were small-scale spatial gradients in food habits. Namely, euphausids were most important in sites sampled east of Seguam Island, but diets were much diverse at sites west of the island. Moreover, stomach fullness was

greater in the eastern region. Although this small-scale variation does not necessarily imply the larger scale patterns that we hypothesized, it does suggest a reasonable basis for anticipating spatial variation in food availability.

3. Compare and contrast food habits patterns with established regional growth patterns. Analysis of these data will form the bulk of Ms. Rand's M.S. thesis research at the University of Washington, beginning in September 2005.
4. Summarize findings in a brief report that can be included in the Stock Assessment and Fishery Evaluation (SAFE) Report. In collaboration with Sandra Lowe, Ms. Rand will prepare a summary of the preliminary findings in September 2005.

PROJECT:

Graduate Student Stipend for Stock Assessment Training and Improvement

PI:
UW: Ray Hilborn

PERSONNEL:
UW: Teresa A'Mar, Doug Kinzey

TASK:
III

NOAA PRIMARY CONTACT:
REFM, AFSC, NMFS

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

OBJECTIVE:

1. Two students, Teresa A'mar and Douglas Kinzey, were funded under this project during 2004/05.

ACCOMPLISHMENTS:

1. Teresa A'Mar presented the results of her research on the ability of several commonly-applied methods of stock assessment to determine whether a stock is above or below its Minimum Stock Size Threshold (MSST) at a symposium. A paper documenting this work was submitted to the proceedings of the conference. Ms. A'Mar also contributed to the stock assessments for rex sole (Gulf of Alaska), plaice (Bering Sea) and Dover sole (Gulf of Alaska) during her internship with the REFM group at the Alaska Fisheries Science Center.

She has also started work on an operational model that could be used as the basis for a Management Strategy Evaluation (MSE) to determine the likely performance of the assessment methods / decision rules used to manage walleye pollock in the Gulf of Alaska. This model will be capable of mimicking the impact of changes over time in the values for biological parameters considered known when conducting stock assessments.

2. **Douglas Kinzey** is developing the mathematical specifications for a multispecies stock assessment tool for application to the data for three of the fish stocks in the Aleutian Islands: walleye pollock, Pacific cod and Atka mackerel. These stocks provide the basis of the main fisheries in the region as well as interacting directly with one another through predator-prey relationships. Kinzey's model expands the single-species approach that is currently used by the REFM to assess these stocks to also include data from stomach sampling (diet database maintained by the Resource Ecology and Ecosystems Management, AFSC). This will allow these stocks to be assessed simultaneously and allow their biological interactions to be quantified within a statistical parameter estimation framework.

PROJECT:
Fisheries Acoustics Research

PI:
UW/AFSC: J. Horne

TASK:
III

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

OBJECTIVES:

1. To characterize walleye pollock aggregations; to quantify the effect of walleye pollock distribution on acoustic survey sampling.
2. To quantify the effect of ontogeny on acoustic backscatter among individual fish
3. To examine the effect of position in beam and yaw on acoustic target strength
4. To increase student involvement and training in fisheries acoustic research

ACCOMPLISHMENTS:

1. Two projects examined walleye pollock spatial distributions and their potential influence on acoustic-based density and abundance estimates. In the first, a sensitivity analysis examined aggregation recognition metrics used to delineate aquatic organism patches within acoustic data. It was found that the aggregation detection algorithm implemented in the Echoview software package is sensitive to changes in acoustic threshold values, in parameters that defined minimum aggregation sizes, connectivity among pixels, and less sensitive to changes in the size of the search ellipse. The next component of this study examined the applicability of landscape ecology metrics to describe the distribution of fish aggregations relative to the distribution of other aggregations and to classify aggregation types. Using ordination and classification techniques, six different 'types' of walleye pollock aggregations were identified ranging from tight, discrete patches to diffuse, pelagic or demersal layers.

   A second project examined the effect of walleye pollock spatial and temporal distributional variance on acoustic-based survey sampling. Mobile acoustic surveys attempt to map and count aquatic organisms without biasing abundance estimates. Horizontal and vertical movements by target species may influence density measurements and net samples during acoustic surveys. Temporal and spatial variability of walleye pollock *(Theragra chalcogramma)* was compared in three sets (2 night, 1 day) of 14.8 km transects in the eastern Bering Sea. Walleye pollock density distributions were also compared to those in the five nearest daytime survey transects. Horizontal density distributions did not change at temporal scales ≤ 4 hours and that spatial variance remained consistent at scales ≤ 2.5 km. Spatial variance density patterns were similar in transects sampled during the day compared to those sampled at night, and in along-shore compared to cross-shore transects. Transects that contained two biological scattering layers could be vertically separated into zooplankton and fish. Spatial variance patterns in the upper zooplankton layer mimicked those of passive tracers while patterns in the lower layer were consistent with those previously observed for mobile nekton. Current sampling resolution of acoustic surveys adequately captures horizontal spatial variance of walleye pollock in the Bering Sea and probably most other gadoid species.

2. Changes in shape and size of swimbladder and body determine backscatter intensities from fish. Acoustic sizes to fish length conversions typically use length frequencies from net catches. A group of 35 Donaldson trout (rainbow-steelhead hybrid) were tagged with passive integrated transponder (i.e. PIT) tags and radiographed at roughly biweekly intervals during an eight month grow-out period. Twenty-four of the 35

fish that were initially tagged survived the 16 rounds of radiographs. Fish growth was linear in length and quadratic in weight. Dorsal swimbladder area increased exponentially with fish length. Allometric growth ratio (i.e. k) values of swimbladder length linearly increased with fish body length. Average swimbladder volumes occupied 3-6% of fish body volume and increased exponentially with fish length. Maximum mean target strength shifted from approximately 80o to 86o through the experimental period indicating a mean shift in swimbladder angle. Mean, predicted acoustic backscatter increased at both 38 kHz and 120 kHz as average fish length increased. Target strengths at 38 kHz significantly exceeded those at 120 kHz at fish lengths less than approximately 150 mm. Mean target strengths at 120 kHz exceeded those at 38 kHz at lengths greater than approximately 280 mm and were more variable. Choice of fish length and model length range influences predicted backscatter intensities.

3. Fish orientation, usually defined as tilt and possibly roll, is always listed as a major influence on fish target strength (TS). Effects of swimming direction (yaw) in combination with beam position on TS have rarely been examined. 38 kHz target tracking data were combined with backscatter model predictions to estimate the influence of yaw and distance-off-axis on Pacific hake (*Merluccius productus*) TS. Length frequency data from trawl catches and tilt angles from target tracking were convolved with predicted backscatter to simulate TS frequency distributions. Tilt and yaw distribution functions were also manipulated independently to assess their influence on TS. Regression analysis of the *in situ* data showed that tilt, distance-off-axis, and the interaction of yaw and distance-off-axis significantly ($p<0.05$) influenced TS. At any yaw and constant tilt angles, modeling experiments showed that TS differences increased with increasing distance off axis. For a 44.4 cm fish at 0º tilt and 10 meters off axis, changes in yaw resulted in as much as a 10 dB difference in TS. Surprisingly, when these TS values are averaged over all yaws there was no significant difference (ANOVA, p». 05) in TS for any tilt as distance-off-axis increases. While individual TS's are influenced by yaw, dispersion yaw angles within a beam can average out this effect.
4. This ongoing project integrates research projects with education and training of students in fisheries and fisheries acoustics. Service activities include participation on NOAA Midwater Assessment and Conservation Engineering (MACE) survey cruises as needed, fostering collaboration between the UW School of Aquatic and Fishery Sciences (SAFS) and the Alaska Fisheries Science Center (AFSC), organizing and administering the SAFS-AFSC summer undergraduate internship program, supervision and mentoring of undergraduate and graduate students, acoustic training of students and government scientists, and participation in academic committees at the School of Aquatic and Fishery Sciences.

All research objectives were met during this reporting period. Manuscripts are being prepared or are submitted from the first three projects summarized above.

PROJECT:

Estimating the Economic Impact of the Steller Sea Lion Conservation Area: Developing and Applying New Methods for Evaluating Spatially Complex Area Closures

PI:
UW: David Layton

PERSONNEL:
UW: Alan Haynie

TASK:
III

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Economists and biologists have recognized that spatial and temporal area-closures may provide an effective means of managing the impact that fisheries have on one another and upon threatened species such as Steller sea lions. To date, however, little work has been done to estimate the economic impact of protected areas on commercial fishing. One very significant protected area in the Bering Sea is the Steller sea lion Conservation Area (SCA), which was first implemented during 1999. The benefits of the SCA consist of improvements to Steller sea lion populations as excluding commercial fishing leaves more prey for sea lions. The primary cost of the SCA is the potential reduction in profits that occurs as boats incur additional costs as they travel to more distant locations and/or experience lower levels of catch or product quality in alternative fishing areas. Estimating the economic impacts of the SCA thus requires explicit modeling of fishing location choice, as it is the aspect of behavior that is directly affected.

OBJECTIVE:

1. To estimate the economic impact of the Steller sea lion Conservation Area, developing and applying new methods for evaluating spatially complex area closures

ACCOMPLISHMENTS:

1. Using observer data from the NMFS NORPAC database, the group examined the change in fishing location choice that occurred with the imposition of the SCA. These data allowed the researchers to work at a NMFS statistical area level or at an ADF&G statistical area level. To make use of these data, the group had previously developed the Expected Profit Model (EPM). The standard discrete choice model predicts location choice in two stages. The first stage involves calculating the expected catch for an area or zone, while the second stage involves estimating how fishers are affected by the expected catch calculated in the first stage, as well by distance and boat specific characteristics, using a discrete choice econometric model. In contrast, the EPM endogenizes expected catch and jointly estimates the parameters (via full information maximum likelihood) that describe expected catch and of the parameters that describe location choice conditional on expected catch. A primary challenge in estimating the economic impact of the SCA is that it overlaps a number of NMFS statistical areas. Using the EPM, the researchers use the ADF&G areas to define smaller sized zones that fit neatly into the SCA. This allows one to simply delete the zones in the SCA to evaluate the post-SCA situation. This has been used to form ex-ante estimates of the impacts of the SCA. It also compared the results of the EPM with the traditional approach.

The original schedule would have had the group completing a peer-reviewed article and presenting the results during 2004. The researchers have made a number of presentations, and are nearly finished with the paper. The late arrival of funding kept the project from meeting its original schedule for completing the research paper. Additionally the group added a number of extensions to the original model, which has taken some additional time.

PROJECT:
Marine Biological Interactions in the North Pacific – Fish Interactions

PI:
UW: B. Miller

PERSONNEL:
UW: K. Aydin, J. Boldt, K. Dodd, R. Hibpshman, J. Jurado- Molina, I. Ortiz, A. Whitehouse

NOAA: P. Livingston

TASK:
III

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center, Resource Ecology and Fisheries Management Division

NOAA GOAL:
Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

This research project focuses on improving ecosystem based fishery management through increased understanding of predator/prey relationships, improved predator/prey models, and development of ecosystem indicators.

OBJECTIVES:

1. To investigate the feeding ecology of North Pacific fishes.
2. To collect stomach, plankton or benthic samples in the field.
3. To estimate and test parameters of single-species, multi-species and ecosystem models.
4. To develop ecosystem indicators.

ACCOMPLISHMENTS:

1. Feeding ecology of North Pacific fishes. A total of 17,270 groundfish stomachs were analyzed in the laboratory. Personnel were trained in stable isotope analysis theory and applications with the aim of conducting extended studies of trophic positioning of species within Alaskan marine ecosystems. Substantial work was performed towards updating the food habits specimen reference collection and preparing it for integration with a web-based application for sample identification.
2. Assisted with the collection of stomach, plankton or benthic samples. Collection and shipboard analysis of groundfish stomachs during the time period totaled 3,437 samples. JISAO personnel covered four cruise legs.
3. Parameter estimation of ecosystem models. Modeling activities focused in the updating of the multispecies virtual population (MSVPA) and the multispecies forecasting model (MSFOR). A new quarterly version of the MSFOR was developed and tested against the previous annual version. Work was continued on a Multispecies Statistical Model (MSM). An interactive website for browsing model results was developed.
4. (i) Comparative ecosystem modeling. Indicators were compared between three ecosystem models developed in the previous year: Eastern Bering Sea, Gulf of Alaska and Aleutian Islands. The Aleutian Islands model was subjected to substantial sensitivity analyses.

   (ii) Ecosystem indicators. The Ecosystem Considerations section of the North Pacific Stock Assessment and Fisheries Evaluation (SAFE) document was updated in the spring and provided to stock assessment scientists to incorporate into stock assessment documents. This contribution was also made accessible on the web for more interactive viewing of time series and data. Work continued on Shelkof pollock spawning anomalies and climate and pollock cannibalism and water column properties.

PROJECT:

Molecular Genetics of Pacific Salmonids

PI:
UW: Kerry Naish

PERSONNEL:
UW: Tricia Lundrigan, James Rhydderch,

TASK:
III

NOAA PRIMARY CONTACT:
NMFS: Dr. Linda Park

NOAA GOAL:
1. Protect, restore and manage the use of coastal and ocean resources through eco-system based management

OBJECTIVE:

1. Develop molecular technology for stock identification.

ACCOMPLISHMENTS:

1. To fulfill this objective two fisheries biologists are working on different aspects of a molecular genetic baseline for the Columbia River basin. They have collected genotype data for 8 microsatellite markers from over 3000 fish from 63 populations representing all ESU's and nearly all major production areas in the Columbia River basin. The group has recently added 9 new populations to the baseline (~430 individuals) and genotyped 15 populations in the Lower Columbia for a second set of 8 microsatellite loci in order to improve genetic resolution in this region.

   The genetic baseline has been extensively analyzed this year for its utility in assigning population of origin to unknown samples from the Columbia River basin. In addition, the data are being used in a combined effort by nine different federal, state and university laboratories for establishing a coastwise genetic database for Chinook. Data were collected for 15 microsatellite loci for 96 Chinook across the geographic range of the species. These data were used to standardize allele designations across participating labs. An additional set of 96 "blind" fish was genotyped at the same loci for competency and validation testing. The baseline was incorporated into the larger coastwise baseline for evaluation of its utility in assigning population of origin to unknown Chinook samples caught in the ocean. Major genetic lineages can be identified genetically with over 90% accuracy (often 98-99%).

   More than 1000 individuals of unknown origin (caught by purse seine in the estuary) have been genotyped for the baseline loci and assigned to their most likely population of origin. Microsatellite data were also collected for baseline loci for 376 Chinook salmon samples derived from harbor seal scat samples between 1994 and 2002. These data were used to determine whether seal predation is negatively impacting protected Chinook salmon stocks, and indeed a large percentage of identified prey items were from the Lower Columbia river ESU, which is listed as Threatened under the ESA. Data were then collected at 3 to 8 microsatellite loci for approximately 550 bone samples (representing 30 harbor seal scat samples) to determine the minimum number of individual salmon prey items present in each scat. The species of each bone was determined by sequencing or allele specific PCR. These data are being used to calibrate bioenergetic models of harbor seal consumption estimates of salmon.

PROJECT:

Ecological Forecasting of Walleye Pollock Recruitment in the Gulf of Alaska and Bering Sea Based on Ecosystem Status and Climate Change Trends

PI
NOAA: B. Megrey

PERSONNEL:
UW: Yong-Woo Lee, Vincent Gallucci

NOAA: S.A. Macklin

TASK:
II

NOAA PRIMARY CONTACT:
NMFS, Alaska Fisheries Science Center

NOAA GOALS:
1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management

2. Understand climate variability and change to enhance society's ability to plan and respond

OBJECTIVES:

1. To assess the performance of the statistical tools currently used to forecast walleye pollock recruitment
2. To examine the adequacy of an existing recruitment prediction scheme, implement improvements, extend the prediction scheme into the Bering Sea, incorporate more ecosystem and climate change data into the analysis, and move the forecast activity forward with the aim of improving stock assessments, building sustainable fisheries, advancing our knowledge of forage fishes, and protecting endangered species.

ACCOMPLISHMENTS:

1. The accuracy of five different recruitment forecasting techniques was evaluated in a controlled simulation setting. The parameters or underlying relationships of actual data, can never really be known, it was chosen to use simulated data with known properties and different levels of measurement error to test and compare the methods, especially their ability to forecast future recruitment states. Methods examined include traditional linear regression, nonlinear regression, Generalized Additive Models, Artificial Neural Networks, Probabilistic Neural Networks and Multinomial Logistic Regression. Each method was compared in its ability to recover known patterns and parameters from the simulated data, as well as to accurately forecast future recruitment states. The researchers, also, applied the methods to published spawner-recruit-environment data from selected fish stocks, namely Norwegian spring spawning herring *(Clupea harengus L.)*. Analysis of controlled simulated data was extended to stochastic Monte Carlo simulations.
2. Finally, the most promising and robust statistical methods were applied to actual Gulf of Alaska walleye pollock spawning biomass, recruitment and environment data in order to provide information useful for supplying management advice.

PROJECT:

1. Spring Gulf of Alaska Ichthyoplankton InterannualTrends Study
2. Comparative response of selected Fish Species Early Life History Strategies to fluctuating environmental conditions in the Gulf of Alaska
3. Early Life History of Pacific Sandlance in the Gulf of Alaska

PI:
UW: Miriam Doyle (supervised by N. Bond)

PERSONNEL:
UW: Mick Spillane

NOAA: Susan Picquelle, Kathryn Mier, Ann Matarese, Morgan Busby, Deborah Blood, Ann Matarese, Morgan Busby

TASK:
II

NOAA Primary Contact:

NMFS/AFSC

NOAA Goal:

1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

OBJECTIVES:

1. To elucidate the potential links between fluctuating ocean conditions and the early life history dynamics of fish species in the northwest Gulf of Alaska. A time-series of Gulf of Alaska spring ichthyoplankton data, 1981-2003, has been examined for interannual trends in abundance, distribution and larval size of numerically dominant ichthyoplankton species in the vicinity of Kodiak Island and Shelikof Strait. Local physical oceanographic data and model output, along with basin-scale climate/ocean indices were utilized to investigate trends in the ichthyoplankton in relation to interannual trends in ocean temperature, circulation, and production in this region.
2. To compare the response of selected fish species early life history strategies to fluctuating environmental conditions in the Gulf of Alaska. Six species were chosen for their dominance in our ichthyoplankton collections and their ecological significance in the Gulf of Alaska ecosystem.

   Capelin *(Mallotus villosus)*, Pacific sandlance *(Ammodytes hexapterus)*, and northern lampfish *(Stenobrachius leucopsarus)* are ecologically important forage fish, and Pacific cod *(Gadus macrocephalus)*, arrowtooth flounder *(Atheresthes stomias)*, and starry flounder *(Platichthys stellatus)* are important components of the groundfish resources in the Gulf of Alaska. These species represent a diversity of life history strategies. This study reviews details of the biology, life history traits and ecology of these six species, and evaluates their individual adaptation and vulnerability to prevailing and fluctuating oceanographic conditions in the Gulf of Alaska
3. To understand the biology and ecology of this key forage species and to investigate the potential stability or vulnerability of their populations in the Gulf of Alaska oceanographic environment.

   Sandlance *(Ammodytes hexapterus)* larvae are the most ubiquitous species in the Gulf of Alaska ichthyoplankton collections and are second in abundance only to walleye pollock larvae. The species is an important forage fish in this ecosystem and contributes significantly to the diet of many species of fish, birds and marine mammals. As a key forage species, it is important to understand its biology and ecology and to investigate the potential stability or vulnerability of Pacific sandlance populations in the Gulf of Alaska oceanographic environment.

ACCOMPLISHMENTS:

1. For the time-series, unique patterns of periodicity and amplitude of variation in abundance are apparent among species. Some commonality is observed, especially for the deepwater spawners (northern lampfish, arrowtooth flounder and Pacific halibut) that display a decadal trend of enhanced abundance during the 1990s. Species-

specific seasonality is apparent in the associations between late spring larval abundance and environmental variables. There is, however, a general trend indicating that basin-scale environmental conditions in February through April, and local-scale conditions in late-March through early-April, are most influential in terms of prevalence of larvae in late spring. Observed species-specific patterns of association between late spring larval abundance and environmental variables seem to reflect geographic distribution and early life history patterns among species. Further work continues at the individual species early life history level to investigate potential mechanisms underlying the observed links between species and environmental variables. This type of ichthyoplankton time-series study shows good potential for identifying levels of resilience or vulnerability of individual species early life history patterns to fluctuating oceanographic conditions. A manuscript is being prepared for submission to the journal *Fisheries Oceanography* by the end of 2005.

2. A manuscript is being prepared for submission to an international marine science journal.

3. A manuscript is being prepared for submission to an international marine science journal during 2006. Results will also be presented at the Annual Larval Fish Conference of the American Fisheries Society in 2006 or another appropriate meeting.

PROJECT:

Analyze Ocean Ambient Sound Data

PI:
UW: Bruce Howe, Kathleen M. Stafford

TASK:
III

NOAA PRIMARY CONTACT:
NMFS, National Marine Mammal Lab, Alaska Fisheries Science Center

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

OBJECTIVES:

Research was focused on analysis of a long-term acoustic data set from the Gulf of Alaska. The primary objectives were:

1. To determine the seasonal and geographic occurrence of large whale vocalizations by species.
2. To use propagation loss models to determine detection distances for each species in order to assess the regional coverage of individual hydrophones.

ACCOMPLISHMENTS:

1. Integration of these data with oceanographic variables is underway in order to produce a predictive model of large whale occurrence in the Gulf of Alaska. These data will be used to study "habitat" (defined by oceanographic conditions) requirements of pelagic species of large whales. Vocalizations of six types of large whale were analyzed including blue (2+ acoustic populations), fin, humpback and sperm whales. All vocalization types showed geographic and seasonal patterns. These acoustic patterns are compared to other data on the animals' occurrence, including sighting and harvest data.
2. Detection distances of all species varied with frequency and were driven primarily by estimates of ambient noise levels in the Gulf of Alaska, suggesting that increases in anthropogenic noise may result in decreased detection distances for large whales. Interpretation of the role of oceanographic variables in whale call reception/detection is continuing. Two manuscripts are in preparation as a result of these data analyses and should be submitted to peer-reviewed journals by the end of the calendar year.

PROJECT:
Growth and development of salmon

PI:
UW: Walton W. Dickhoff

PERSONNEL:
NOAA: Paul Parkins

TASK:
III

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

The salmon populations of the North Pacific Ocean show significant interannual variation and decadal trends in fish numbers, body size, and age at maturity. A trend of declining size of Pacific salmon has been observed in recent years. It has been suggested that the decrease in size of adult salmon is due to changing conditions of the ocean ecosystem during the final life stage of salmon. Differences in growth rates and size also affect age of reproductive development. It is not clear to what extent these fluctuations are caused by external changes in climate or ocean productivity. The immediate goal of this study is to conduct studies of the endocrine and physiological systems controlling growth and development to better understand factors affecting the salmon life cycle and body size. Eventually, we hope to develop a set of indices of blood hormones and growth regulatory factors that could be used to estimate growth rates of fish based on single time samples. These indices may be more precise and accurate than conventional methods of estimating growth rates, for example, by analysis of scale or otolith patterns, of RNA/DNA ratios.

Specific studies are aimed characterizing the endocrine mechanisms controlling growth and how these factors change when growth is manipulated to influence development, including reproduction.

OBJECTIVE:

1. To understand the control of salmon growth and development by internal and external factors. The long-range goal of the project was to develop applications to better understanding of how climate change may affect the growth of salmon in the freshwater and marine phases of the salmon life cycle.

ACCOMPLISHMENTS:

Two studies were conducted:

1) A study on the effect of fasting and ration change on the plasma levels of growth hormone, insulin-like growth factor-I (IGF-I), insulin, and insulin-like growth factor binding protein (41-kDa IGFBP).

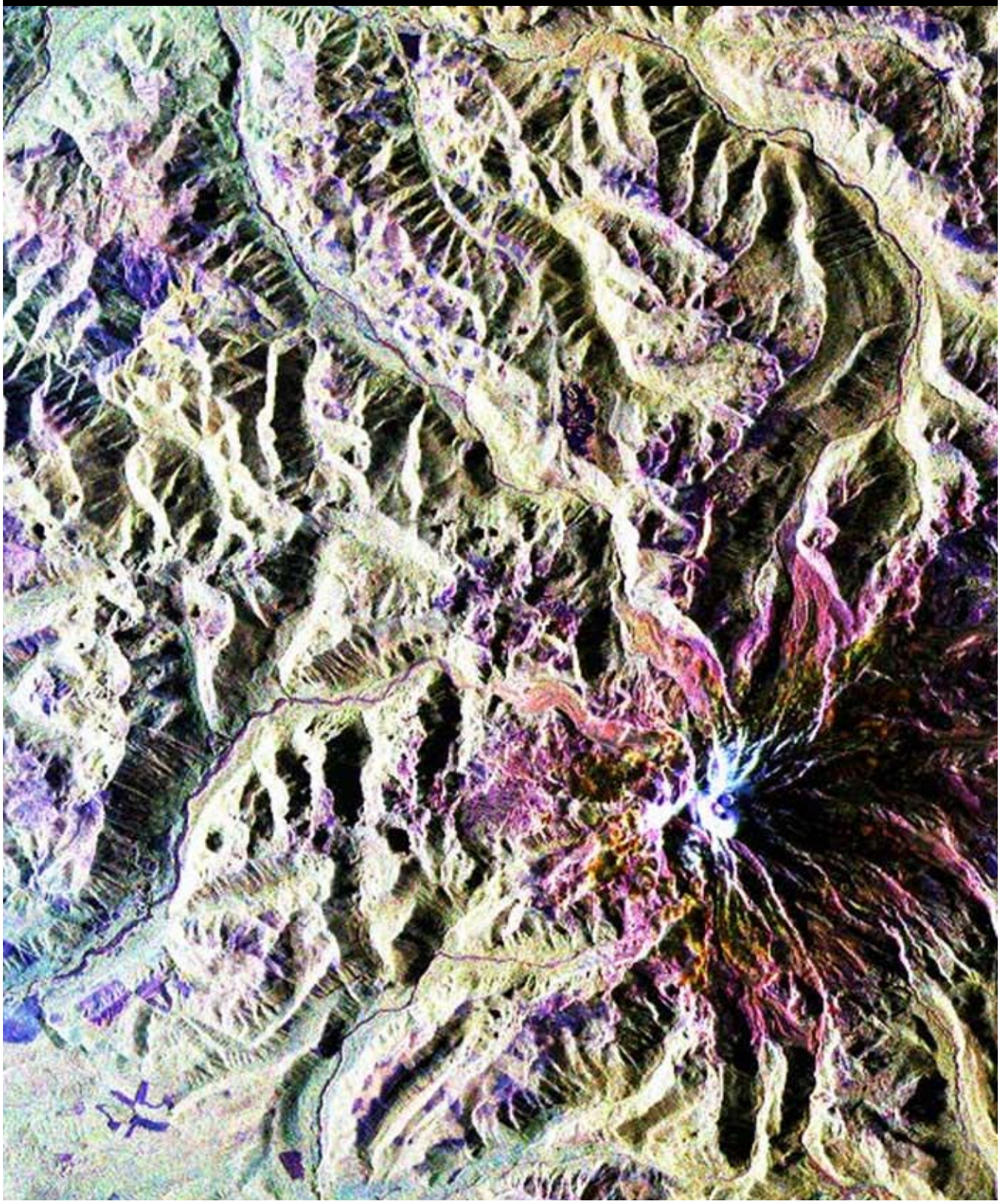
2) The effect of fasting on a form of IGFBP that is inhibitory to growth. Results of these studies show the complexity of the endocrine control of growth in salmon and provided several potential candidates for stimulatory and inhibitory growth factors that could be used to assess growth rate of fish in field samples.

These studies have been published.

This project is a collaboration between the University of Washington, School of Aquatic and Fishery Sciences and Northwest Fisheries Science Center, NMFS, NOAA. Prof. Walton Dickhoff will oversee the UW part of the project. The National Marine Fisheries Service will provide laboratory and office space and daily interaction between project personnel and Center staff of the REUT Division. Staff biologists of the University of Washington will use NMFS facilities and may operate NMFS vehicles as part of their work on the project.

JISAO Research Projects

CLIMATE



PROJECT:

Thermal Modeling and Prediction (TMAP) – Product Development

PI:
NOAA: S. Hankin, UW: J. Callahan

TASK:
II

NOAA PRIMARY CONTACT:
PMEL

NOAA GOALS:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVES:

1. To provide software solutions that integrate and disseminate data and data products over the Internet.
2. To provide support for sites utilizing Live Access Servers (LAS) for data access products over the Internet.
3. To develop data management solutions that make large volumes of oceanographic data accessible to users on demand in real-time.

ACCOMPLISHMENTS:

1. (i) The Live Access Server (LAS). The Live Access Server is currently installed at approximately 50 institutes worldwide and provides access to terabytes of ocean, atmosphere and climate data. In the last year LAS was enhanced year in several way to ease installation and improve robustness. New application programmer interfaces allow the creation of customized interfaces. Enhancement of LAS features and products is ongoing.

   (ii) Observing System Monitoring Center (OSMC) at NOAA Office of Global Programs. A custom interface has been designed for the OSMC that connects to the Live Access Server to provide data visualizations and products. This interface provides an instantaneous overview of the state of the global ocean monitoring system. Users can query a database for actual observations or investigate grided data.

2. (i) Argo Global Ocean Data Assimilation Experiment (GODAE) server in Monterey. The Live Access Server was installed at the Navy's Fleet Numerical Metereology and Oceanography Center and is currently being used to provide access to data and data products. The GODAE server in Monterey is designated as an official US GODAE server for real time data products.

   (ii) IPRC server in Honolulu. The Live Access Server was installed at the Asia Pacific Data Research Center (APDRC) at the University of Hawaii. The APDRC server is designated as an official US GODAE server for archive data and data products.

3. (i) Carbon Data Management. Project personnel are working with the Carbon Dioxide Information Analysis Center at Oak Ridge National Lab to design a data management system that will provide real-time access to a unique collection of ocean carbon measurements including 'underway' data, profiles and time series. An LAS has been set up at CDIAC that provides direct access to underway data from cruises on board the NOAA ship Ron Brown.

   (ii) Pacific Region Integrated Data Enterprise (PRIDE). This project integrates the current state-of-the-art data assimilation model outputs for the Pacific Islands regions with real-time and historical observations served from many distributed sources and provide access to them through a simple Web browser interface for Pacific Island end-users and researchers.

   (iii) National Data Buoy Center (NDBC). Project personnel are working with the National Data Buoy Center to make their OPeNDAP served data available through an LAS interface. Work on this customized interface is ongoing and will be demonstrated at NDBC in August 2005.

PROJECT:
Tropical Atmosphere-Ocean Interaction

PI:
NOAA: M. McPhaden

PERSONNEL:
UW: P. A'Hearn, W. Cheng, D. Dougherty, C. Fey, M. McCarty, S. Moon, S. Noor, R. Rodrigues, Y. Serra, L. Stratton, D. Zhang, D. Zimmerman

NOAA: X. Zhang

TASK:
II

NOAA PRIMARY CONTACT:
Office of Global Programs

NOAA GOAL:
2. Understanding Climate Variability and Change

PROJECT DESCRIPTION:

JISAO research on tropical atmosphere-ocean interaction seeks to improve understanding and prediction of El Niño and the Southern Oscillation (ENSO). The centerpiece of the ENSO observing system is the Tropical Atmosphere Ocean (TAO) mooring array, designed to monitor variability in the tropical upper ocean and at the surface. NOAA and JISAO scientists at PMEL maintain the TAO array. In combination with the TRITON array maintained by Japanese scientists in the western Pacific, it is comprised of 70 moorings at 11 different longitudes, spanning the equator from 8°S to 8°N. In addition to monitoring ENSO, data from the array are used for ENSO forecasting and a variety of oceanographic and climate research studies. The array provides long-term, large-scale context for process oriented field studies such as the Eastern Pacific Investigation of Climate (EPIC). It supports carbon cycle studies in the Pacific, by providing access to ship and buoy platforms and by providing a physical oceanographic and meteorological context in which to interpret chemical measurements. Ships servicing the TAO array also provide a platform for the regular launch of Argo floats.

Complementing the TAO array in the tropical Pacific is the Pilot Research Moored Array in the Tropical Atlantic (PIRATA), maintained by NOAA and JISAO scientists at PMEL in collaboration with institutions in Brazil and France. This array of 10 moorings provides data to advance our understanding and ability to predict intraseasonal-to-decadal variations in the climate of the Atlantic sector. Together, TAO and PIRATA are managed through the TAO Project Office at PMEL. Research related to several aspects of ocean-atmosphere interaction and the role of the ocean in climate is conducted within this programmatic framework.

OBJECTIVES:

1. To ensure high quality and timely access to moored time series data for climate research.
2. To contribute to our understanding of the ENSO cycle through an analysis of the 2004-05 El Niño event.
3. To better understand intraseasonal variability and its links to climate.
4. To advance the understanding of decadal variability in the tropical oceans.
5. To investigate the role of the atmospheric boundary layer and SST in maintaining east Pacific synoptic scale disturbances.
6. To understand the relationship between local wind stress forcing in the eastern equatorial Pacific and sea surface temperature variability associated with ENSO
7. To establish an initial moored buoy array in the Indian Ocean for climate studies

ACCOMPLISHMENTS:

1. Providing TAO data to the scientific community via the Internet. Research carried out at JISAO and elsewhere using data from the TAO/TRITON and PIRATA arrays depends critically on the collection, quality control, archival, and web-based display and dissemination of mooring data sets. At JISAO, considerable effort is devoted to providing easy access to high quality multi-variate time series through the TAO web page (http://www.pmel.noaa.gov/tao/). Between July 2004 and June 2005, TAO web pages received nearly 25 million hits and delivered approximately 120,000 mooring data files to the international community.

2. 2004-05 El Niño. The 2004-05 El Niño was one of the weakest of the past 50 years. Warm SST anomalies were concentrated near the date line and were at most 1.5°C in late 2004. The ocean and atmosphere were not strongly coupled during the event since, with the exception of February 2005, anomalous deep atmospheric convection near the date line was weak and variable. As a result, the El Niño had limited impact on the climate system outside in the western Pacific. The event was also unusual in that it followed the conclusion of the 2002-03 El Niño by only one year and was not preceded by an elevated heat content precursor along the equator. Anomalous convection and westerly wind activity in the western Pacific was significantly modulated on intraseasonal time scales, some of which was related to the atmospheric Madden-Julian Oscillation originating over the Indian Ocean. Wind-forced intraseasonal Kelvin waves were a prominent in thermocline depth and SST variations along the equator during both the onset and maturation phase of the event. The interplay between large-scale seasonal-to-interannual ocean-atmosphere dynamics and higher frequency intraseasonal variability in the evolution of this event is presently under investigation using TAO/TRTON and other data sources.

3. Intraseasonal variability in the Pacific and Atlantic. In the Pacific, the role of intraseasonal variability in the ENSO cycle is under investigation, especially with regard to the development of the 2004-05 El Niño, as discussed above. In the Atlantic, significant intraseasonal variability in surface atmospheric and oceanic properties with periods of 30-70 days has recently been discovered. This variability is evident in the North Atlantic Oscillation and its Southern Hemisphere counterpart; it may in part be related to the Madden-Julian Oscillation, which originates over the Indian Ocean. Fluctuations at periods of 30-70 days significantly affect tropical surface winds, latent heat fluxes, and sea surface temperatures. In the northern tropical Atlantic, an analysis of the upper ocean heat balance indicates that intraseasonal surface temperature variations are largely driven by latent heat fluxes associated with intraseasonal wind variations. Like intraseasonal variability in the tropical Pacific Ocean, this variability may affect the evolution of longer-term seasonal-to-decadal time scale variability in the Atlantic.

4. Observational and climate model diagnostic studies. Decadal trends and variability of the shallow meridional overturning circulation, i.e., the subtropical cells (STCs), in both the Pacific and Atlantic oceans have been investigated using historical hydrographic data and the Simple Ocean Data Assimilation (SODA) analysis product. It is found that the decadal trends and variability of the circulation transport are strongly associated with the North Atlantic Oscillation in the Atlantic, and the Pacific Decadal Oscillation in the Pacific. In the Pacific, pycnocline transport time series is strongly anti-correlated with sea surface temperature (SST) anomalies in the central and eastern tropical Pacific, implying that variations in meridional overturning circulation are directly linked to the decadal variability and trends in tropical SST. In the Atlantic, initial indications are that variations in STC pycnocline transport are smaller than in the Pacific and have less influence on interannual to decadal time scale changes in SST.

- In an effort to understand and assess the uncertainty of the future climate change projections, the relationship between tropical SST and STC transports in the Pacific has been explored in 18 model simulations of 20th century climate from 14 state-of-the-art coupled climate models. Significant correlation exists between meridional transport convergence and tropical SST in the majority of the models over the last half century. The magnitude of transport variability on decadal time scales however is underestimated in the models, and 50 year long trends towards decreasing transport convergence as appear in the observations are generally poorly simulated. While pycnocline transport variability is shown to play an important role in tropical Pacific SST variability on decadal time scales in most of the models, the role of the meridional overturning circulation on SST trends is less clear in the models than in the observations.

- Simulations of an eddy-resolving ocean general circulation model in the Pacific basin driven by historical atmospheric forcing were used to investigate the most recent decadal changes in the Pacific STCs. It was found that wind driven changes in ocean transports associated with the STCs play a central role in regulating tropical Pacific climate variability on decadal time scales. The modeling results were also compared to observations to help the group

to better understand some of the uncertainties associated with the previous observational work, particularly with regard to western boundary transport estimates. Lastly, a 500-year integration of a fully coupled global ocean-atmosphere-land-sea ice model using the NCAR Community Climate Model (CCM3) and Miami Isopycnic Coordinate Ocean Model (MICOM) was finished. Diagnostics on the coupled model output has been initiated.

5. Atmospheric boundary layer processes. TAO buoy data, together with observed outgoing long wave radiation (OLR) and NCEP/NCAR reanalyses have been used to study easterly wave structure and the role of boundary layer processes in the eastern tropical Pacific. Easterly waves dominate sub-seasonal variability in cloudiness and meridional wind in both the tropical Atlantic and east Pacific, and are a significant source of hurricanes in these regions. In FY2005 the group completed the analysis of the vertical and horizontal structure of these disturbances in the east Pacific. The relationship between OLR variability associated with easterly waves and surface winds and moisture at the TAO buoys is consistent with analyses of NCEP/NCAR 1000 mb reanalysis winds and moisture, both indicating similar phasing of convection with respect to easterly wave wind anomalies. Having determined the horizontal and vertical structure of easterly waves in the east Pacific, it is now time to address the question of how seasonal and interannual variability in the background SST, boundary layer structure, and vertical wind shear modulate the wave activity in the region. This study continues through FY2006, but the funds shifted to alternative sources at another university during early FY2005.

6. Role of wind stress forcing. Vertical advection of temperature is the primary mechanism by which ENSO time scale SST anomalies are generated in the eastern equatorial Pacific. Variations in vertical advection are mediated primarily by remote wind-forced thermocline displacements, which control the temperature of water upwelled to the surface. However, during some ENSO events, large wind stress variations occur in the eastern Pacific that in principle should affect local upwelling rates, the depth of the thermocline, and SST.

   The impact of these wind stress variations on the eastern equatorial Pacific has been addressed using multiple linear regression analysis and a linear equatorial wave model. The regression analysis indicates that a zonal wind stress anomaly of 0.01 N m^{-2} leads to approximately a 1°C SST anomaly over the Niño3 region (5°N-5°S, 90°-150°W) due to changes in local upwelling rates. Wind stress variations of this magnitude occurred in the eastern Pacific during the 1982-83 and 1997-98 El Niños, accounting for about 1/3 of the maximum SST anomaly during these events. The linear equatorial wave model also indicates that, depending on the period in question, zonal wind stress variations in the eastern Pacific can work either with or against remote wind stress forcing from the central and western Pacific to determine the thermocline depth in the eastern Pacific. Thus, zonal wind stress variations in the eastern Pacific contribute to the generation of interannual SST anomalies through both changes in local upwelling rates and through changes in thermocline depth. Positive feedbacks between the ocean and atmosphere in the eastern Pacific are shown to influence the evolution of the surface wind field, especially during strong El Niño events, emphasizing the coupled nature of variability in the region.

7. International planning and field work. The Indian Ocean is unique among the three tropical ocean basins in that it is blocked at 25°N by the Asian land mass. Seasonal heating over this land mass sets the stage for dramatic monsoon wind reversals and intense summer rains over the Indian subcontinent and adjoining areas of Southeast Asia. Recurrence of these summer monsoon rains is critical to agricultural production that provides life-sustaining support for hundreds of millions of people in the region. The Indian Ocean is also important as the spawning ground of the Madden-Julian Oscillation and other phenomena that can affect climate variability outside the basin (e.g. ENSO and Atlantic climate variability). Despite the importance of the Indian Ocean in the regional and global climate system though, it is the most poorly observed and least well understood of the three tropical oceans.

   To help remedy this situation, JISAO and NOAA/PMEL scientists, together with a group of international climate scientists, have developed a plan for systematic, sustained, and comprehensive in situ observations in the Indian Ocean to complement both present and planned space-based satellite measurements. The plan includes

a strategy for the establishment of moored buoy array, which in essence represents an expansion into the Indian Ocean of the TAO array (Fig. 1). The first NOAA supported moorings of this array, i.e. 4 ATLAS moorings and 1 ADCP mooring, were deployed on the Indian research vessel Sagar Kanya in October-November 2004. Data are being transmitted in real-time to shore via Service Argos (see Fig 2) and analyzed to improve our understanding of ocean-atmosphere interactions in the region.

PROJECT:
Low-Latitude Cloud Feedbacks on Climate Sensitivity.

PI:
UW: C. S. Bretherton

PERSONNEL:
UW: M. Wyant

TASK:
III

NOAA PRIMARY CONTACT:
NOAA Office of Global Programs, Dr. Ming Ji

NOAA GOALS:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVES:

1. To contribute to the coordination of Cloud Process Team (CPT) activities.
2. To compare simulations of tropical clouds in different climate models.

ACCOMPLISHMENTS

1. A second CPT group meeting was held in Seattle on 20-21 October 2004 at NCAR, with approximately 40 participants, including all the funded CPT investigators, many of the advisory group members, and invited guest speakers Phil Austin (UBC) and Knut von Salzen (CCC-Victoria), who are Canadian experts on cloud parameterization and cloud feedbacks, and who have helped coordinate a Canadian multi-PI study of cloud feedbacks in Canadian climate and forecast models. Four tasks were identified for the upcoming year, and interest groups for each task were formed:
   (a) Development of a suite of global model metrics implemented across all three CPT models that will enable the group to convincingly demonstrate progress in simulating clouds.
   (b) Implementation of Pincus/Klein column generator for representation of sub grid cloud and radiation processes in the NCAR model, and exploration of how cloud fraction, microphysics and radiation parameterizations can take advantage of this approach.
   (c) Hypotheses for low-latitude boundary layer cloud feedbacks on climate sensitivity.
   (d) Exploration of single-column datasets from the CPT models
2. A paper has been submitted comparing the simulated low-latitude clouds and response of clouds to climate perturbations such as CO2 doubling in the 3 CPT models, using monthly-mean vertical velocity to sort the cloud response by dynamical regime (with mean ascent corresponding to rainy regions with extensive cumulonimbus, and subsidence corresponding to regimes dominated by boundary-layer clouds such as shallow cumulus or stratocumulus. This paper is currently undergoing a first revision in response to reviewer comments.

PROJECT:

Aerosol Optical Properties: Measurement of Light scattering & Absorption on the NOAA Research Aircraft & Vessel of Understanding Radiative Transfer

PI:
UW: David Covert

NOAA PROJECT OFFICER:
Atmospheric Composition and Climate, Kea Duckenfield,

TASK:
III

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Atmospheric aerosol particle concentrations are significantly elevated above natural concentrations in regions where there is extensive urban and industrial development. These aerosols affect health, visibility, radiation balance and the overall chemistry of the air. Aerosols affect the radiative balance of the earth, atmosphere system directly by scattering and absorbing sunlight, and indirectly by acting as cloud condensation nuclei, thereby influencing the albedo, geographical extent and life-time of stratus and stratocumulus clouds and the precipitation fields associated with those clouds.

OBJECTIVES:

1. To make in-situ measurements of the optical properties of the regional aerosol in the Northeastern US and coastal North Atlantic region as part of the NOAA field experiment entitled, New England Air Quality Study – Intercontinental Transport and Chemical Transformation (NEAQS-ITCT 2004). Focus was to be on measurement of aerosol light extinction, scattering and absorption coefficient at three wavelengths in the visible range. The measurements were to be made on the NOAA P3 aircraft in coordination with NOAA Aeronomy Laboratory. An additional set of similar measurements was to be made on the NOAA Research Vessel, Ronald H. Brown.

ACCOMPLISHMENTS:

1. Due to technical difficulties having to do with the specifications of the wing pod for the NOAA P3 that was provided by NOAA Aeronomy, the optical package that was developed and installed in the pod could not be attached to the P3 wing and flown during NENA 2004.

The aerosol instruments that were installed in the pod, tested and shipped to the P3 operations center in Florida in June 2004 in advance of the field campaign were:

1) one, three-wavelength (450, 550 & 700nm), sub-micrometric, low-RH (15 to 30%) nephelometer (TSI model 3563, St Paul, MN),

2) two three-wavelength (460, 530 and 660nm), sub-micrometric, low-RH light absorption photometers (modified PSAP, Radiance Research, Seattle, WA),

3) a fluorinert based particle counter (Modified model 3010, TSI, St. Paul MN)

4) an isokinetic inlet with >95% passing efficiency for aerosol of Dp<1m for flight altitudes up to 6500m.

5) a flow control system to maintain constant temperature and the impactor-based size cut of 1m independent of aircraft pressure altitude and ambient temperature.

After it was determined that the pod could not be mounted on the wing, the two absorption photometers were removed and installed in other ICARTT aircraft, DOE Gulfstream and NASA DC-8, for use by Dr. Nels Laulainen PNNL and Dr. Tony Clarke at University of Hawaii, respectively. This enhanced their observational database by providing multiwavelength absorption data to complement their existing multiwavelength scattering measurements.

The 2004 experiment on the NOAA RV Ron H. Brown with in-situ measurements of aerosol optical properties, extinction, scattering, and absorption coefficients, using a newly developed, three

wavelength Optical Extinction Cell (OEC), coupled with an integrating nephelometer (TSI Model 3561) and a filter-based absorption photometer (PSAP, Radiance Research).

The goals were to directly measure the aerosol light extinction of the submicrometer aerosol with the OEC to determine an in-situ value for the absorption coefficient by difference between extinction and scattering coefficients. Combining the aerosol scattering and extinction yields the single scattering albedo key parameter in estimating aerosol direct radiative forcing, as well as the Ångström exponents for absorption and scattering and the hemispheric backscatter ratio. A secondary, collaborative goal was to compare the two measures of extinction to the aerosol extinction coefficient measured by the NOAA Aeronomy Cavity Ring-Down (CRD) instrument.

The results showed a good correlation between the extinction coefficient and the sum of the absorption and scattering coefficients and also between the extinction coefficient measured with the two different instruments. But the determination of the absorption by difference was not satisfying due to the large uncertainty in the OEC measurement during this campaign and the difficulty in determining absorption as the difference between two relatively large values. The CRD had significantly less noise than the OEC but had not been incorporated in the sampling system to readily permit direct comparison to the nephelometer to determine the absorption by difference. Improvements in the OEC stability and the OEC, CRD, nephelometer sampling system will improve the in-situ measurements of absorption coefficients, and determination of its humidity dependence in the future.

PROJECT:

Development of Hydrologic Nowcast & Forecast Products using Land Data Assimilation

PI:
UW: Dennis P. Lettenmaier

PERSONNEL:
UW: Andy Wood

TASK:
III

NOAA GOALS:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

3. Serve Society's Needs for Weather and Water Information.

OBJECTIVES:

1. To develop the real-time monthly to seasonal hydrologic forecasting system for the western U.S. focusing primarily on increasing the number of streamflow forecasting points, increasing the level of automation of spinup and forecasting procedures, and interacting with agency forecasting groups.

ACCOMPLISHMENTS:

1. Regular real time hydrologic forecasts for the western US domain continued to be made once/month, augmented by bi-monthly updates in the Colorado River basin from January-April, and for the Pacific Northwest from March-May.
2. Based on the guidance of USDA National Resources Conservation Service National Water and Climate Center (NWCC), 30 new forecast points were calibrated for the Colorado River basin, and development was started on about 60 new points for the Missouri River basin (a forecast domain expansion). Additional points are also under development in the Klamath and Yakima River basins, the Great Basin and upper Rio Grande River basin. The upper Missouri River basin is the first step toward expanding the domain eastward to the Mississippi River basin. To assist with the process of calibrating streamflow simulations, an automatic calibration routine is under development, but this work is not yet complete.
3. Interactions with the NWCC (formalized in a Memorandum of Understanding with the University of Washington) also led to the development of basin average water balance analyses and displays that will soon appear on the forecast system website (which has been also been redesigned), and to regular exchanges of forecast results and analyses immediately prior to the NWCC forecast coordination with the offices of the Colorado River Basis Forecast Center (CBRFC) and the Northwest River Forecast Center (NWRFC). An effort was also made to install and run elements of the forecast system within the NWCC forecast office in Portland, OR, but institutional constraints and efficiency considerations argued for an arrangement in which forecasts would be run at UW and shared with NWCC instead. In the end, one UW water supply forecast (for the Virgin River, in February) was used directly as the coordinated official forecast.
4. Forecast results were also presented at over a dozen meetings and prepared for a Washington State emergency water group in connection with the regional drought. In addition, forecast system presentations were made to the western US RFCs and NOAA Office of Hydrologic Development in an effort to identify areas of potential future collaboration.
5. The methods for generating critical spin-up period model forcings were also revisited, and a completely automated version of this software was designed and tested in a 1/2 degree resolution implementation spanning the entire continental US (CONUS). Provisionally named the *UW Experimental Surface Water Monitor,* it has become an operational hydrologic/drought monitoring

system in its own right, and is consulted regularly by authors of the US Drought Outlook. For this effort, a set of climate index stations for the CONUS domain was developed and new automatic data streams were implemented using the NOAA Applied Climate Information System. A website was created for displaying daily (real-time) updates to the data products, as well as an archive of linked products extending back to 1915.

PROJECT:
Monitoring Ice Thickness in the Western Arctic.

PI:
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TASK:
III

NOAA PRIMARY CONTACT:
John A. Calder

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVE:

1. To study the variability of the ice thickness in the Arctic basin and the best locations to monitor both the mean ice thickness in the basin and for monitoring the spatial variability of the annual mean thickness.

ACCOMPLISHMENTS:

1. Model simulations of arctic sea ice and ocean systems were used to determine the major spatial and temporal modes of variability in the ice thickness. A coupled ice–ocean model is forced with daily NCEP Reanalysis surface air pressure and surface air temperature fields for the period 1951–2003 with the analysis of the results performed for the 51-yr period 1953–2003.
2. Ice concentration data and ice velocity data (beginning in 1979) were assimilated in order to further constrain the simulations to match the observed conditions. The simulated ice thins over the study period with the area of greatest thinning in a band from the Laptev Sea across the pole to Fram Strait. The thinning rate has been greatest since 1988. The major spatial modes of variability were determined with empirical orthogonal functions (EOFs) for the ice thickness within the Arctic Ocean.
3. The first three EOFs account for 30%, 18%, and 15% of the annual mean ice thickness variance. The first EOF is a nearly basin-wide pattern and the next two are orthogonal lateral modes. Because of the nonstationary nature of the ice thickness time series, significantly different modes are found if a shorter period of record is analyzed. The second and third principal components are well correlated with the Arctic Oscillation.
4. The model results were used to simulate an observation system and to then determine optimal mooring locations to monitor the basin wide mean ice thickness as well as the spatial and temporal patterns represented in the EOF analysis. The nonstationary aspect of the ice thickness limits the strength of the conclusions that can be drawn.

In the next year research will concentrate on two areas of interest. One is to identify locations where there is a large amount of variability in the ice thickness between the different coupled ice-ocean models used in the Arctic Ocean Model Intercomparison Project (AOMIP) to determne where ice-thickness monitoring instruments would be most helpful in determining which modeling approaches are more accurate. A second area of study will be the Ice Mass Balance Buoys deployed over the last several years by PMEL and the Cold Regions Research and Engineering Laboratory. How can the data from these buoys be most effectively used to improve model simulations of the ice pack? The data from the buoys will be compared to model output and, if appropriate, methods of assimilating the data into the model will be devised.

PROJECT:

Wavelet Analysis of Bering Sea Temperature Time Series

PI:
UW: Donald Percival

PERSONNEL:
UW: Muyin Wang
NOAA: James Overland; Harold Mofjeld

NOAA PRIMARY CONTACT:
PMEL

TASK:
III

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVES:

1. To understand the long term patterns of surface air temperatures in the Bering Sea.

ACCOMPLISHMENTS:

1. The study shows a change in the climatological structure of the Bering Sea in the late 20th century, at present of unknown origin,and occurring earlier than the well-known 1976/1977 shift. These climatological results further support the concept that the southeast Bering Sea may have been dominated by Arctic species for most of the century, with a gradual replacement by sub-arctic species in the last 30 years.

PROJECT:

Oceanic Observations of Climate Change in the Arctic Sub polar Zone

PI:
UW: P. Rhines , Charles Eriksen

TASK:
III

NOAA PRIMARY CONTACT:
Arctic Programs, John Calder

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVES:

1. To support the deployment of an acoustic-Doppler current profiler in Barrow Strait, as part of the International Arctic-Subarctic Ocean Flux (ASOF) monitoring of Arctic outflows.
2. To support fieldwork in the Labrador Sea, making use of "Seagliders".

ACCOMPLISHMENTS:

1. In Barrow Strait, in the Canadian Arctic Archipelago, NOAA supported instrumentation is providing 3 years' observations of the ocean flow from Arctic to Atlantic Oceans, a key part of the global climate system. Dr. Prinsenberg of Bedford Institute of Oceanography, Canada, has successfully deployed the newly conceived 'Icycler', a profiling moored ctd/current sensor in this program. The deployments were carried out as planned in summer of 2004 and results from 2003 analyzed.
2. Two Seagliders were launched west of Greenland in September 2004. A second winter of successful hydrographic surveying of the Labrador Sea was carried out by the two autonomous undersea vehicles (AUVs), launched in Davis Strait. The AUVs set new records for distance and duration, collecting 2500 hydrographic profiles. A total of 5000km of sections were collected.

The Seagliders have discovered the source of the low-salinity layer that dominates the near-surface Labrador Sea and controls deep convection and water-mass creation in this important source of the global meridional overturning circulation. This buoyant upper layer promotes an exceptionally strong region of springtime biological productivity. The Seagliders have also made repeated sections of the intense boundary currents that form the Atlantic sub polar gyre. The Davis Strait sections are the most detailed surveys of this important exchange flow ever made. A poster describing the 2003/4 Seaglider expedition can be viewed at http://www.ocean.washington.edu/research/gfd/Seaglider-poster-iva.pdf

PROJECT:
Monitoring the Eurasian Basin of the Arctic Ocean

PI:
UW: Ignatius G. Rigor

PERSONNEL:
UW: Andy Heiberg & Mark Ortmeyer

TASK:
III

NOAA PRIMARY CONTACT:
Arctic Research Office, John A. Calder, Director

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVES:

1. To establish a network of instruments to monitor changes in the thickness, or more accurately, mass balance of the sea ice cover in conjunction with the Arctic Ocean Observing System. This focus recognizes the role that the sea ice cover plays as both an integrator and indicator of climate-related changes in this complex atmosphere-ice-ocean system.

ACCOMPLISHMENTS:

1. The ice thickness component of the observing network is an international collaboration, which complements existing activities, including the North Pole Environmental Observatory (NPEO) and the International Arctic Buoy Program (IABP), which are coordinated by the Polar Science Center, Applied Physics Lab, University of Washington (PSC/APL/UW). The "Ice Mass Balance (IMB)" drifting buoys are equipped with a atmospheric barometers, air thermistor, ice thermistor string, which extends through the thickness of the ice cover, and acoustic sensors measuring the position of the top and bottom surfaces of the ice When possible, these IMB buoys are collocated with buoys that monitor other geophysical variables such as ocean temperature and salinity to form "Automated Drifting Stations (ADS)".

   This suite of instruments allows the researchers to monitor and, more importantly, to attribute changes in the thickness of the ice cover. The seafloor mooring is equipped with ice profiling sonar, providing a measurement of changes in the thickness of the ice cover at a particular location within the basin.

Since the beginning of the program a total of 11 drifting buoys have been deployed; 3 currently remain in operation (http://iabp.apl.washington.edu/dailyimbads.60day.g), and one seafloor mooring has been established in the Chukchi Sea, at (75°06 N, 168°00 W).

The future objective of this component of the observing system is to maintain and develop this instrumentation network, so that 12 drifting buoys and 2 moorings are in operation at all times. This summer, the plan is to deploy 6 – 8 more IMB buoys. Data from this instrumentation network are processed by the PSC/APL/UW, and are available via the website http://www.crrel.usace.army.mil/sid/IMB/index.htm. These data can be used to validate satellite-based instrumentation, for forcing, validation and assimilation into numerical climate models, and for forecasting weather and ice conditions.

PROJECT:
Argo: A Global Array of Profiling Floats

PI:
UW: Stephen C. Riser

PERSONNEL:
UW: Kurt Heinze, Dale Ripley, Dana Swift

TASK:
II

NOAA PRIMARY CONTACT:
Dr. Steve Piotrowicz

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVE:

1. To continue participation in the Argo program. This international program is designed to deploy 3000 profiling floats in the world ocean (approximately 300 km resolution over the globe) that will collect profiles of temperature and salinity over the upper 1000 m of the world ocean at approximately 10 day intervals. This is the first subsurface global ocean observing system.

   The US is committed to providing about half of these floats. For the past 2 years the US has been providing about 300 floats per year, split among 3 institutions (SIO, WHOI, and UW). In the past year funds were received to build and deploy 125 floats. The UW floats were deployed in the Indian Ocean, the Antarctic, and the Pacific. Most are working properly. At the present time the data are being used to examine the state of the Indian Ocean Dipole, the Pacific Decadal Oscillation in the North Pacific and long-term (decade to century) scale of variability of salinity in the N. Pacific.

ACCOMPLISHMENTS:

1. In 2005, the most critical region for deploying floats continues to be the South Pacific where the coverage remains thin due to the difficulty in finding suitable means (ie, ships or aircraft) to deploy the floats. To remedy this situation, funds were received from NOAA through JISAO to charter a vessel for several months that could deploy Argo floats in the tropical and subtropical South Pacific.

   Originally, it was planned to use a Russian research vessel for this work. After investigating the availability of vessels, it was decided instead to use a small research vessel based in Wellington, New Zealand, operated by the National Institute of Water and Atmospheric Research of New Zealand. In all, this vessel deployed 110 Argo floats supplied by UW and 108 floats supplied by SIO in the S. Pacific and tropical Pacific region during calendar 2005. The deployment of these floats has greatly increased the available database for the South Pacific, and the data from them are already being assimilated into climate models. In the coming year, the charter vessel will be used to deploy Argo floats in the South Indian Ocean.

PROJECT:
Correction of Systematic Error in the TOVS Radiance.

PI:
Axel Schweiger

NOAA PRIMARY CONTACT:
Arctic Research, John Calder, Director

TASK:
III

NOAA GOALS:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVE:

1. To identify, quantify, and mitigate errors in TOVS radiances caused by changes to satellite orbits, instruments, and/or calibration method. The plan is to produce a 22-year (or more) record of TOVS radiances and retrieved products that are as error-free as is practicable, given available information and resources. Many of the known errors should be regionally and seasonally independent, but it is suspected that some may be peculiar to or exacerbated by Arctic conditions. Thus while the efforts will be global, the focus will be primarily Arctic. The expected product of this investigation will be a data set of tremendous value both for geophysical retrievals with sufficient accuracy to identify changes since 1979, as well as for direct assimilation by numerical atmospheric models. The database of high-latitude rawinsondes, many of which have not been incorporated into the operational Global Telecommunications System or assimilated by reanalyses, together with collocated satellite radiances, will also be of great value for further studies.

ACCOMPLISHMENTS:

1. Additional rawinsondes have been acquired from field experiments and ships, reformatted, then sent to the National Environmental Satellite, Data, and Information Services (NESDIS) to join existing database. A historical rawinsonde database designed for use in this project has been completed. Screening protocols are being adapted and finalized. The complete level 1-b TOVS radiance database is being transferred from University of Washington to NESDIS. A relational database containing TOVS radiances and collocated raobs has been completed.

Many issues identified and resolved, IDL programs written by A. Schweiger were provided to NESDIS staff to aid in data structure generation and consistency checking.

The test year of raobs collocated with NOAA-11 HIRS and MSU radiances completed. Data from NOAA-12 are in process. Collocated raobs with radiances for SHEBA year (fall 1997 to fall 1998) are being generated.

Website and diagnostic tools have been created and made available to access and monitor collocation data (http://www.orbit.nesdis.noaa.gov/smcd/opdb/poes/polarsearch/).

Two radiative transfer models (RTTOV and 3R) have been acquired and configured for computation of brightness temperatures from rawinsonde profiles and compared to satellite-observed values. Computed systematic differences between brightness temperatures from each forward model have been computed to assess errors contributed by models.

Merged radiance/rawinsonde collocation data sets have been generated by NESDIS with corresponding surface meteorological observations to facilitate cloud detection/filtering, verify surface temperature, and provide additional verification of sounding quality.

A scheme has been developed to extend incomplete rawinsondes to higher altitudes using database called TIGR (Thermodynamic Initial Guess Retrieval) that is a component of the 3I TOVS retrieval algorithm.

A software has been developed to link NESDIS collocation database and quality assurance scheme with radiative transfer models. The PI has assisted NESDIS in identifying and resolving a variety of problems and inconsistencies in rawinsonde data and collocation procedure.

An initial set of brightness temperature biases for all HIRS channels has been generated for the entire year of 1995. Initial results suggest that the methodology is successful, as differences between observed and calculated brightness temperatures have expected magnitudes and signs owing to likely cloud contamination (observed would be colder if undetected cloud is present).

Biases in some channels vary substantially with season; in winter the values are more negative, suggesting the existence of some undetected clouds below the surface-based inversion.

All groups involved in this project are on track, as outlined in the milestone chart included in the project proposal. A decision has been made to forego the task of obtaining and evaluating the CARDS (now called IGRA) database of rawinsondes, as it has been able to assemble sufficient data for the purposes. The final year of this project will include the following tasks:

- Complete collocation database for all years for which there are TOVS radiances
- Finalize calculations of bias corrections
- Apply corrections to Level 1b TOVS radiances
- Reprocess TOVS radiances into geophysical products
- Prepare manuscript describing generation data sets: collocated radiances with radiosondes, corrected level 1b radiances, and reprocessed TOVS products.
- If time allows, develop user-friendly interactive web interface to facilitate access to collocation database.

PROJECT:

Downscaling Pacific Northwest Climate

PI:

UW: Edward Miles

PERSONNEL:

UW: Eric Salathé

TASK:

III

NOAA PRIMARY CONTACT:

NOAA/Office of Global Programs

NOAA GOAL:

2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

OBJECTIVE:

1. To support climate impacts studies for the Pacific Northwest by providing regionally specific projections of climate change.

ACCOMPLISHMENTS:

1. Regional climate modeling: A high-resolution climate model of the Pacific Northwest based upon the MM5 mesoscale weather model has been developed. A graduate student, Patrick Zahn, supported by the Center for Science and the Earth System (CSES), is undertaking much of the model development and validation. Professor Clifford Mass in the UW Department of Atmospheric Sciences is participating in this effort and brings expertise in mesoscale meteorology and numerical forecasting for the region. This model is currently being used to downscale simulations from the National Center for Atmospheric Research-Department of Energy (NCAR-DOE) Parallel Climate Model (PCM). To match the climate model grid spacing of approximately 300 km, nested grids of 135, 45, and 15 km resolution are being used.

   The use of nudging in this model is an important distinction to other approaches. Nudging preserves the large-scale state provided by the global model. Thus, the downscaling provides the regional meteorological details consistent with the large-scale state without attempting to improve the large-scale state, which is assumed to be well resolved by the global model. The treatment of land-surface in the model has been improved to better account for the seasonal cycle in soil properties.

2. Support for Climate Impacts Applications. Project staff are collaborating with an EPA STAR project on the effects of climate change on air quality, headed by Professor Brian Lamb at Washington State University. For this project, they are providing regional climate simulations using the MM5 regional model to downscale Parallel Climate Model (PCM) simulations of present-day and climate-change conditions. Global warming, population growth, and land use change are closely interrelated forces that may cause significant changes in air quality and human health within the US. Assessing the potential impact of global change requires a comprehensive numerical modeling approach that explicitly incorporates the effects of global change. The lead investigators on this collaborative project are Brian Lamb, Washington State University; Clifford Mass, University of Washington; Alex Guenther, National Center for Atmospheric Research; and Susan O'Neill, USDA Forest Service, Pacific Northwest Research Station.

PROJECT:
Center for Science in the Earth System

PI:
UW: Edward Sarachik, Edward Miles

PERSONNEL:
UW: V. Agostini, A. Ball, D. Battisti, D. Fluharty, R. Francis, A. Hamlet, R. Hoskins, I. Kamenkovich, A. Karpov, A. M. Kimball, D. Lettenmaier, Z. Levy, J. Littell, D. McKenzie, N. Mantua, T. Mitchell, S. Morlock, P. Mote (also is State Climatologist, R. Norheim, R. Palmer, D. Peterson, E. Salathé, A. Snover, B. Trask, N. Van Rheenan, J. Michael Wallace, L. Whitely-Binder, P. Zahn

NOAA: D. E. Harrison Pacific Northwest National Lab: R. Leung
Consulting Economists: D. Reading, R. Slaughter

TASK:
III

NOAA OFFICES:
CDEP – Ming Ji
OGP – Caitlin Simpson

NOAA GOALS:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

2.Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

3. Serve Society's Needs for Weather and Water Information

The Center for Science in the Earth System (CSES) performs integrated research on the impacts of climate on the U.S. Pacific Northwest (PNW) by combining and integrating expertise in climate dynamics, ecological dynamics, hydrologic dynamics, and institutional and policy analysis. The CSES also researches the application of climate information in regional decision-making processes in support of the regional aspects of an eventual Climate Service. CSES is comprised of two groups:

1. The Climate Dynamics Group (CDG)
2. The Climate Impacts Group (CIG).

OBJECTIVES:

1. To enhance our understanding of climate dynamics
2. To enhance our understanding of the role of climate in the functioning and management of coastal and ocean resources
3. To enhance the region's capacity to plan for and respond to climate impacts by evaluating climate impacts on Pacific Northwest resources and institutional arrangements, and supporting use of climate information in decision-making processes.
4. To support climate impact studies for the Pacific Northwest
5. To support NOAA and climate research committees

ACCOMPLISHMENTS:

1. (i) Thermohaline circulation. Research is continuing on the general question of behavior of thermohaline circulation under climate change, the role of intermediate water in setting the North Atlantic density gradient, and the general role of intermediate water and its correct representation in climate models.

   (ii) Equatorial biases in coupled climate models. Research continues on the westward extent of cold water on the equator and how it is modulated by the annual cycle out of phase. A meeting focusing on equatorial biases in coupled GCMs is being planned by Kinter, Schneider, and Sarachik for September 2005.

   (iii) PDO and global SSTs. The relation between the Pacific Decadal Oscillation (PDO) recent trends in global SST is under investigation.

2. (i) Laying the groundwork for an integrated assessment of a coastal watershed. Issues for a horizontal integrated assessment of climate impacts in a coastal watershed are under examination.

   (ii) Climate impacts on Harmful Algal Blooms (HABs) in the coastal zone. Post-doc funding has been secured for research on the role of climate variation in HABs and the predictability of HAB events.

   (iii) Revisiting the inverse-production regime for Pacific salmon. Research designed to describe

and better understand the characteristic patterns of salmon production variability in the NE Pacific, especially since the early 1990s, has been initiated.

(iv) Stakeholder meetings on climate and salmon management. Two meetings have been conducted with regional salmon managers and researchers on the role of climate in salmon management and recovery in the Columbia River basin and Puget Sound. Details on the meetings are available at http://www.cses.washington.edu/cig/outreach/workshops.shtml.

3. (i) 20th century trends in snowpack, runoff, and soil moisture in the western U.S. Collaborative research between Western Water Assessment/Cooperative Institute for Research in Environmental Sciences and CSES, examining 20th century trends in climatic and hydrologic variables over the western U.S., has been completed, resulting in three papers. The temperature and precipitation records and VIC simulations have been used in several adjunct studies as well.

(ii) Changes in 20th century flood and drought risks. Systematic changes in flood and drought risks over the 20th century are being assessed using temperature data that have been "detrended" to remove strong temperature trends in 20th century climate records.

(iii) Climate-driven variability and trends in mountain snowpack. The sensitivity of snowpack to temperature and precipitation along a transect of the mountain ranges in British Columbia to Southern California is being assessed.

(iv) Climate impacts on water use and allocation in Idaho. An "end-to-end" impact analysis for the Snake River basin in Idaho that considers the impacts of climate variability and change on water allocation in the basin and the economic changes resulting from those changes in allocation is being developed.

(v) Climate impacts on forests and forest productivity. The response of Douglas-fir, an ecologically and economically important timber species in the Pacific Northwest, to climate variability is being assessed. In cooperation with the Western Mountain Initiative program, CSES staff are investigating how climate variability affects a wide range of terrestrial and aquatic resources in western U.S. mountain systems.

(vi) Climate variability and forest fires. Efforts are underway to determine how regional climate patterns from 1916-2003 affected the annual fire burn area in the western U.S., and to quantify how climate variability and topographic constraints affected fire occurrence at different spatial scales over the past 400 years in the Okanogan, Wenatchee, and Colville National Forests in Washington State.

(vii) Climate impacts on energy production. Research has been completed assessing the role of climate variability from 1916-2002 in determining energy supplies and demands in the PNW and California and the predictability of these relationships has been examined. Evaluation of the impacts of climate change on hydropower production at the Hells Canyon complex in Idaho is continuing. An energy forum with major Puget Sound utilities to regularly meet and discuss climate, climate forecasts, and implications for energy production and fish flows has been established. Staff are exploring ways to improve winter and spring/summer forecasts of natural flow at Ross Dam (Seattle City Light).

(viii) Climate change impacts for Puget Sound. A preliminary examination of the implications of climate change for Puget Sound was conducted. This included a broad literature review and new research on climate change impacts to freshwater inputs into Puget Sound.

(ix) Climate impact studies on metropolitan water supplies. Work is progressing on evaluating the potential impacts of climate change on water supplies for the City of Seattle, the Cascade Water Alliance (representing eight municipalities and districts in the greater Seattle-Tacoma area), and communities within the Tualatin (Oregon) River basin. Details on the studies are available at: http://www.tag.washington.edu/projects.html.

(x) Snohomish basin salmon habitat improvements plan. The potential impacts of climate change on Chinook salmon recovery plan alternatives for the Snohomish River Basin in Washington State are being explored.

(xi) Modeling climate impacts on stream temperature. Tools for assessing the impacts of climate change on stream temperature and aquatic wildlife are under development.

(xii) Climate change and PNW ski areas. Examined the viability of PNW ski areas in light of projected climate change impacts.

(xiii) Assessing institutional capacity to adapt to climate impacts. An evaluation of institutional changes that have improved systemic capacity to adapt to climate and growth-related stresses in Idaho's Snake River basin has been completed. A review of the potential for and constraints on water markets as a potential response to climate impacts in the Yakima (Washington), Klamath (Oregon), and Snake (Idaho) river basins has been initiated.

(xiv) GIS-based decision support tool for evaluating fine-scale climate impacts. A GIS-based decision support tool for exploring the impacts of climate change at a variety of scales and developing adaptive strategies is under development. Major emphasis is placed on designing and developing an online database and user interface to provide data about past and future climatic and hydrologic conditions as well as other contextual spatial information.

(xv) Mid-range streamflow forecasts for Puget Sound utilities. Mid-range (up to nine month) water resource forecasts for major water supplies in Puget Sound are under development. Forecasts are available at: http://www.tag.washington.edu/projects/midrange.html.

(xvi) Stakeholder meetings on climate and water resource management. The Climate Impacts Group (CIG) conducted annual fall climate and water resource forecast meetings in Portland, Oregon and Boise, Idaho, and a special workshop on the 2005 winter drought in March 2005. Details on the meetings are available at http://www.cses.washington.edu/cig/outreach/workshops.shtml.

4. (i) New statistical downscaling methods. Statistical downscaling methods tailored to the Pacific Northwest have been developed and these methods have been used to downscale several global climate change simulations distributed by the Intergovernmental Panel on Climate Change. The downscaled data have been applied to hydrologic modeling and can be used ultimately to illustrate important differences among the ability of global models to simulate large-scale patterns controlling Pacific Northwest climate.

(ii) Ongoing hydrologic studies for climate change assessments. New data processing techniques to produce hydrologic climate change scenarios at weekly and daily time scales have been developed.

(iii) Extending climate records for the western U.S. Records of temperature and precipitation from 1915-2003 for the western U.S. have been collected and new techniques developed to create temporally consistent gridded data sets suitable for trend analysis.

(iv) Climatic and hydrologic data resources. Climate records for the western U.S. and some derived records (e.g., spring snowpack for the PNW) have been added to the CSES website. The climate data are available at ftp://ftp.hydro.washington.edu/pub/hamleaf/vic_met_data/. The snow archive is available at ftp://ftp.hydro.washington.edu/pub/hamleaf/snow_archive/.

5. (i) NOAA Climate Working Group. Jonathan Overpeck at the University of Arizona and Ed Sarachik at CSES are planning retreats to organize NOAA research and response programs.

(ii) Involvement in international climate science committees. Philip Mote is participating in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change as a lead author for the chapter on observed changes in snow cover, extent, and depth. Ed Sarachik serves as head of the IRI International Science and Technology Advisory Committee. Nathan Mantua served on the "Responding to Change" panel for the Study of Environmental Artic Change (SEARCH) and the "Fisheries and Ecosystem Responses to Recent Regime Shifts in the North Pacific" for PICES.

PROJECT:
Regional Weather Analysis & Prediction

PI:
UW: Clifford Mass

PERSONNEL:
UW: G. Hakim, R, Torn, S. Dirren, Richard Steed

TASK:
III

NOAA GOALS:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

3. Serve Society's Needs for Weather and Water Information.

OBJECTIVE:

1. To improve NOAA's ensemble data assimilation and forecasting systems, with emphasis on performance in regions of complex terrain.

ACCOMPLISHMENTS:

1. During the past year there has been considerable progress on several of the project goals. A grid-based bias correction scheme has been developed and tested. Currently, minor improvements to this scheme are being made and during the next month bias-corrected grids will be provided to the Northwest NWS offices in a real-time mode. Under the project there has been continued progress in improving and evaluating the regional ensemble prediction system, with a recent extension to 72-h. Also under this project, a new quality control system suitable for complex terrain was developed and tested and new verification methods for high-resolution predictions have been evaluated.

   The University of Washington's research-grade ensemble Kalman filter was released as a real-time operational ensemble data assimilation and forecasting system on 23 December 2004. This functioning system realizes a major goal of the UW CSTAR proposal, and is in fact the first such system in the world. Graduate student Ryan Torn is largely responsible for creating and maintaining the system, which has been up continuously since launch (http://www.atmos.washington.edu/~enkf). Preliminary performance estimates suggest that the short-range error statistics of this system are comparable to those for the major operational centers. The PIs described these and other accomplishments in seminars and meetings at NCEP and NOAA headquarters in April 2005.

PROJECT:

Surface Ocean $^{13}C/^{12}C$ Measurements: a tracer of anthropogenic CO_2 uptake

PI:
UW: Paul Quay

TASK:
III

NOAA GOAL:
2. Understand climate variability and change to enhance society's ability to plan and respond.

NOAA PRIMARY CONTACT:
Office of Global Programs

OBJECTIVE:

1. Measure the change in the $^{13}C/^{12}C$ of dissolved inorganic carbon (DIC) in the surface ocean in order to determine the rate of oceanic uptake of anthropogenic CO_2 using, first, atmospheric CO_2 and $^{13}CO_2$ budgets and, second, ocean models of CO_2 and $^{13}CO_2$ uptake.

ACCOMPLISHMENTS:

1. Sample Collection – The group's approach to obtain the greatest spatial and temporal coverage of the del-^{13}C change in the surface ocean is to use Volunteer Observing Ships (VOSs) for sample collection. Seawater samples for the analysis of the $^{13}C/^{12}C$ of the DIC can be collected while underway using the ship's seawater intake line. These samples can be preserved for several years if the sample is poisoned and sealed against air. During the past year, they have collected del-^{13}C-DIC samples on several ships including the *Polar Sea* Coast Guard ice breaker between Seattle and McMurdo, Antarctica, the *Polarstern* a German research vessel between Bremen, Germany and Cape Town, S. Africa, *Waikato Columbus* a container ship between Seattle and Auckland, NZ, (three times), the *Atlantic Meridional Transect* (AMT) cruises between England and S. Africa, the *FICARAM* cruises between Spain and Argentina, the *L.M. Gould* cruises between Punta Aranus and Antarctica, the *Astrolabe* cruises between Tasmania and Antarctica. There are a few other VOSs that they intend to incorporate into this sampling network. They collected a total of approximately 800 samples for del-^{13}C analysis on these cruises over the last year.

   Del-^{13}C Measurements- To date project staff have measured the del-^{13}C-DIC on approximately 550 samples collected on these VOSs. The most noticeable outcome of the del-^{13}C-DIC samples measured to date, has been the significant del-^{13}C decrease in the surface waters of the North Atlantic Ocean over the last decade. A comparison of the del-^{13}C measurement made during the A16N cruise (65°N to 5°S along 25°W) during July 2003 in the N. Atlantic with a cruise (NOAA RITS93) along the same cruise track in July 1993, indicates that the del-^{13}C of the surface waters have decreased substantially especially in the subpolar waters north of 0 degrees N. The surface ocean del-^{13}C decrease north of 40°N is greater than 0.4 per mil over the decade interval between cruises, exceeding the atmospheric del-^{13}C decrease is approximately 0.3 per mil over this interval. Furthermore, the surface ocean del-^{13}C decrease is significantly correlated with increase in phosphate and salinity in the subpolar latitudes. Thus a portion of this subpolar del-^{13}C decrease is likely due to changes in ventilation and/or photosynthesis and respiration rates.

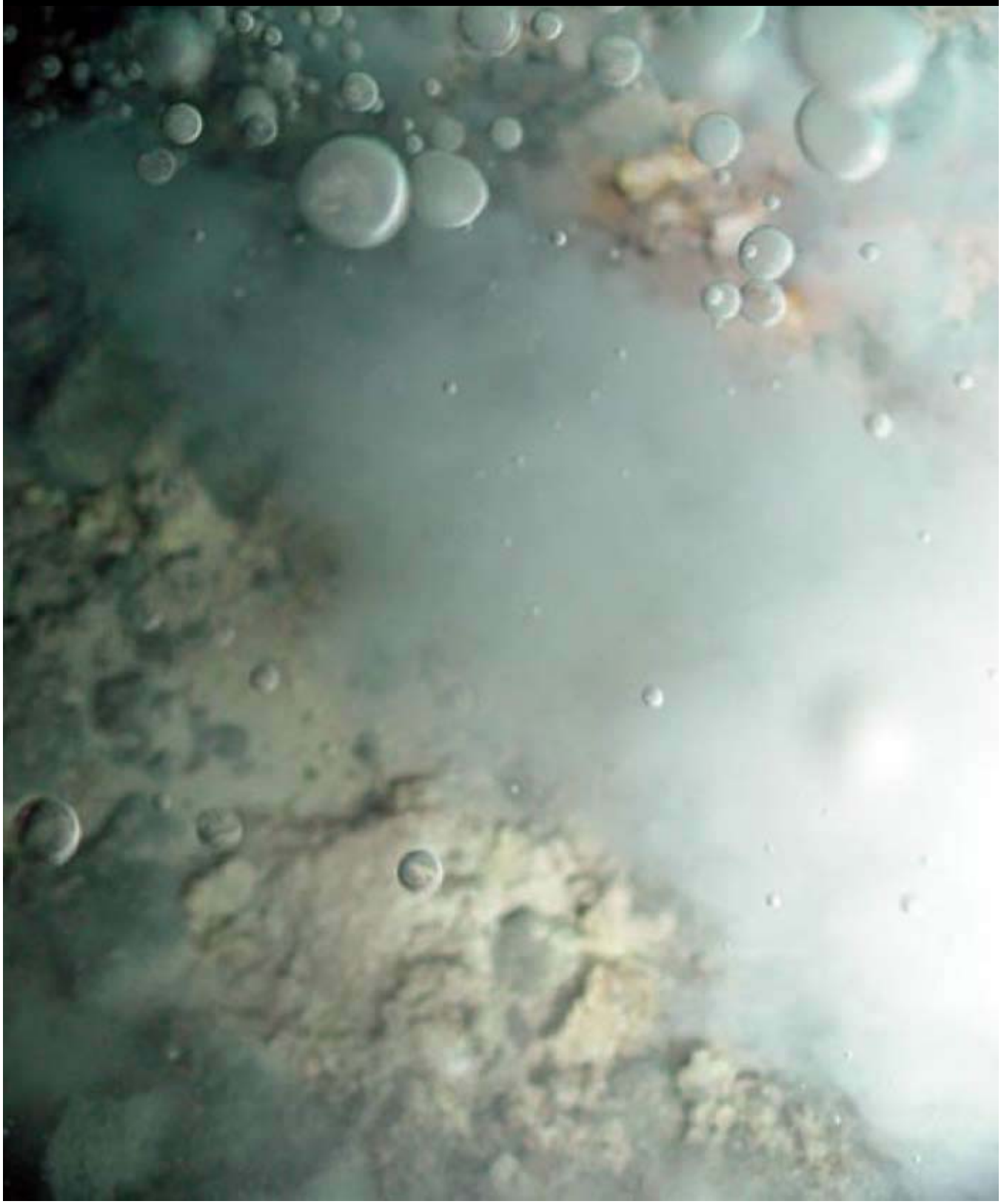
   The researchers have extended their estimate of the del-^{13}C changes in the surface ocean of the Atlantic to the entire Atlantic Ocean basin using VOS sample collections on the AMT, Polarstern, Hesperides and Gould cruises and adding del-^{13}C measurements during TTO in the 1980s by C.D. Keeling (Scripps). It was found that the greatest surface ocean del-^{13}C decrease has occurred in the subtropical gyre (up to 0.25 per mil per decade) with smaller changes in the subpolar and Southern Ocean (less than 0.1 per mil per decade) yielding a basin-wide average

del-^{13}C decrease of 0.16 ‰ per decade. The deepest penetration of the anthropogenic del-^{13}C change occurs in the subtropics (up to 1000m) with shallower penetration in the equatorial Atlantic (less than 300m). The greatest depth-integrated del-^{13}C change over the last 20 years occurs in the subtropics and substantially smaller changes (4x) in the equatorial Atlantic and little change in the Southern Ocean.

The group is in the midst of comparing these anthropogenic del-^{13}C changes to those simulated by a GCM (Princeton's MOM).

JISAO Research Projects

ENVIRONMENTAL CHEMISTRY



PROJECT:
PMEL-JISAO Atmospheric Chemistry - Aerosol Program

PI:
NOAA: Tim Bates

PERSONNEL:
UW: D. Covert, S. Doherty, D. Hamilton, J. Johnson, T. Miller, K. Schultz

NOAA: P. Quinn, D. Coffman

TASK:
II

NOAA OFFICE:
Office of Global Programs, Health of the Atmosphere Program

NOAA GOALS:
1. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

2. Serve Society's Needs for Weather and Water Information

Results from three international field experiments have been used to develop a parameterization that quantitatively describes the relationship between particulate organic matter (POM) mass fraction and the humidity dependence of light scattering, for sub micrometer particles composed of POM and sulfate.

The PMEL-JISAO Atmospheric Chemistry - Aerosol Program is designed to quantify the spatial and temporal distribution of natural and anthropogenic atmospheric aerosol particles and to determine the physical, meteorological and biogeochemical processes controlling their formation, evolution and properties. Recent efforts are grouped under 3 objectives:

OBJECTIVES:

1. To assess the regional climate and air quality impacts of atmospheric aerosol particles through measurements of their chemical and radiative properties.
2. To quantify the oceanic source of atmospheric sulfur.
3. To improve our capability to observe, understand, predict, and protect the quality of the atmosphere through national and international partnerships.

ACCOMPLISHMENTS:

1. Aerosols directly affect climate and air quality through the scattering and absorption of incoming solar radiation. Measurements of aerosol properties during integrated field campaigns provided data for the validation of regional models that are used to estimate aerosol direct radiative forcing and the validation of algorithms used to retrieve aerosol optical depth from satellite observations. In addition, the measurement of regional aerosol plumes allowed for the linking of aerosol sources to climate and air quality impacts. The overall payoff is a reduction in the uncertainty associated with estimates of aerosol direct radiative forcing (climate) and aerosol haze plumes (air quality).

   During July/August 2004, the PMEL-JISAO Atmospheric Chemistry – Aerosol Group participated in the International Consortium for Atmospheric Research on Transport and Transformation (ICARTT) field experiment in the Gulf of Maine. The group led the ship component of the experiment spending 46 days at sea aboard the NOAA RV *Ronald H. Brown*.

   During ICARTT, several urban plumes from Boston were tracked across the Gulf of Maine to quantify the chemical processing of the gases and aerosols over time. On 1 August the ship tacked downwind to follow a power plant plume embedded within the urban Boston plume. During this 11-hour period, the ship crossed the plume 5 times over a downwind distance of 100 km. While not a Lagrangian experiment it was possible to observe over time/distance

1) an "aging" of the hydrocarbon mixture, 2) a decrease in the NOx mixing ratio with a increase in the ozone, PAN, nitric acid and nitrate aerosol mixing ratios, 3) a decrease in the SO2 mixing ratio and the formation and growth of new particles, and 4) an increase in the organic aerosol concentration. These data are currently being used to quantify the chemical processing of the urban plume.

Measurements during ICARTT, coupled with those from INDOEX (Indian Ocean Experiment) and ACE Asia (Aerosol Characterization Experiment – Asia) are the basis for the development of a parameterization that quantitatively describes the relationship between particulate organic matter (POM) mass fraction and the humidity dependence of light scattering, for submicrometer particles composed of POM and sulfate. This parameterization may be combined with chemical transport model-generated aerosol concentration fields to improve the accuracy of calculations of direct climate forcing and visibility impairment.

2. DMS (dimethylsulfide) is biologically produced in the surface ocean and is the major natural source of sulfur to the atmosphere. In the atmosphere, DMS is transformed into sulfate aerosol particles, which scatter solar radiation back to space and alter the properties and lifetimes of clouds. The concentration of DMS in surface seawater and thus its flux to the atmosphere vary spatially and temporally as a result of the physical, biological and chemical properties of seawater.

   - A database of seawater DMS concentrations is essential for global chemical transport and climate models to accurately predict climate change scenarios. PMEL-JISAO scientists have developed and are currently maintaining a web-based interactive database containing the thousands of global observations of surface seawater DMS concentrations have been collected by various institutions in the national and international community since the early 1980's. The database (http://saga.pmel.noaa.gov/dms/) now contains over 30,000 seawater DMS measurements.
   - Additional measurements of surface seawater DMS concentrations are needed to assess the temporal and spatial variability, particularly in higher latitudes. The Automated PMEL Underway-DMS system operated onboard the NOAA R/V Ronald H. Brown during the ICARTT field study in July/August 2004, collecting seawater DMS data to add to the global database.

3. PMEL/JISAO hosts the International Global Atmospheric Chemistry (IGAC) Core Project Office with funding from NOAA, NSF and NASA. The goal of IGAC is to promote and facilitate international atmospheric chemistry research that will lead to a better understanding of the Earth System. Dr. Sarah Doherty, JISAO Research Scientist, is the Executive Officer of the Seattle Project Office (http://www.igac.noaa.gov/). During the past year IGAC held it's 8th biennial International Conference, organized 2 international specialty workshops and has initiated 2 new international research projects.

PROJECT:
Chlorofluorocarbon Tracer Program

PI:
NOAA: John Bullister

PERSONNEL:
UW: Rolf Sonnerup, Frederick Menzia

TASK:
II

NOAA PRIMARY CONTACT:
NOAA Office of Global Programs

NOAA GOAL:
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and respond

OBJECTIVES:

1. To monitor the uptake of anthropogenic chlorofluorocarbons (CFCs) and sulfur hexafluoride (SF6) into the ocean on decadal timescales and to use this information to estimate the rates and pathways of ocean ventilation processes.
2. To use observed CFC tracer fields to help evaluate global ocean model simulations and to estimate the oceanic uptake of other tracer gases, including carbon dioxide

ACCOMPLISHMENTS:

1. JISAO scientists have participated on CLIVAR Repeat Hydrographic/CO_2/Tracer expeditions in the Atlantic Oceans, repeating sections occupied a decade earlier. The goal of this program is a systematic and global re-occupation of select hydrographic sections to quantify changes in storage and transport of heat, fresh water, CO_2, CFCs and related parameters. Changes in observed CFC fields are being used to estimate water mass formation rates and to evaluate the importance of physical vs. biological processes in observed subsurface dissolved oxygen changes.
2. The group has also developed analytical methods for ultra-trace level measurements of sulfur hexafluoride in seawater. This anthropogenic compound is rapidly increasing in the atmosphere and has the potential to provide valuable information on the rate of uptake of gases in the ocean and for estimating water mass ventilation rates. These methods have been tested on visits to HOTs monitoring site.
3. Project personnel have worked with carbon investigators to utilize CFCs to estimate the global oceanic uptake of anthropogenic carbon dioxide.

PROJECT:
NOAA-VENTS

PIS:
UW: David Butterfield, Joseph Resing

PERSONNEL:
UW: K. Roe, G. Lebon

TASK:
II

NOAA GOAL:
1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Mid-ocean ridge hydrothermal systems have been studied intensively since the late 1970s, but there are still many geologic environments on the seafloor that have not been investigated, and recent discoveries remind the researchers that there is still much that has not been seen on the seafloor. Microbial diversity in hydrothermal ecosystems is not well understood. At present, the classic mid-ocean ridge (or divergent plate margin) environment is relatively well documented, but volcanic arcs (convergent plate margin) and off-axis environments are not.

OBJECTIVES:

1. To explore the ocean to locate and characterize neovolcanic areas, their associated hydrothermal ecosystems, and their impact on the oceans.
2. To understand how submarine hydrothermal systems evolve over time and how they respond to local and regional tectonic or volcanic events.

   Very little is known about how hydrothermal systems change when they are perturbed by geological events, and the prospect of recording data and collecting samples immediately after an event promises to yield new insight into the workings of hydrothermal systems. Volcanic events have been seen to give rise to microbial blooms, but the chemical conditions that lead to increased biomass in vent fluids have not been measured.

3: To understand the link between the chemical environment and microbial communities in hydrothermal vents.

   Hydrothermal ecosystems are highly diverse and complex. The understanding of hydrothermal ecology is in its infancy, and new data is required to advance knowledge in this area.

ACCOMPLISHMENTS.

1. (i) JISAO scientists played important roles in the exploration and sampling of an off-axis, non-volcanic hydrothermal system where seawater reacts with rocks exposed from the earth's mantle. Unlike volcanic systems directly on the mid-ocean ridge axis, a large portion of the heat coming from this system may result from exothermic chemical reactions between seawater and mantle rocks (peridotites). Under NSF support, in 2003 a large number of samples were obtained from the off-axis hot spring site near the Mid-Atlantic Ridge, the Lost City hydrothermal field. In July, 2005, the Lost City site was the target of a unique study (funded by NOAA Ocean Exploration) using a broadband connection to the *Hercules* ROV on the NOAA ship Ron Brown to allow scientists on shore to participate in research more than 4000 miles away (http://www.oceanexplorer.noaa.gov/explorations/05lostcity/welcome.html). This was the first expedition of its kind, where the scientific direction was located at the University of Washington with real-time video, audio and data links to the ship and the remotely operated vehicle working in the mid-Atlantic.

   (ii) JISAO scientists have been key participants in a multi-year project funded by NOAA Ocean Exploration to study volcanic arcs in the western Pacific, an area of the ocean that was virtually unknown to science. To date there have been two field expeditions to the undersea portion of the Mariana Volcanic Arc between Guam and Iwo Jima. The first expedition (March 2003) generated high-resolution bathymetric maps and water-column surveys of hydrothermal signals. The second expedition (March/April 2004) used the mapping work to locate, sample, and explore seafloor volcanic and hydrothermal features on six submarine volcanoes. Some remarkable

discoveries were made along the way, including the first direct observation of volcanic activity in the deep sea, overlapping hydrothermal and photosynthetic ecosystems, and venting of liquid carbon dioxide (see http://oceanexplorer.noaa.gov/explorations/04fire/). A third expedition brought the manned submersible *Pisces V* on the U. of Hawaii ship *KaimiKai-O-Kanaloa* to explore and sample submerged volcanoes on the Tonga-Kermadec arc (http://www.oceanexplorer.noaa.gov/explorations/05fire/welcome.html). These multi-year, international expeditions represent a significant and rapid advance in the knowledge of undersea volcanoes on oceanic arcs, and the samples collected will provide significant insight into geochemical processes on convergent margins. The results to date confirm that arc volcanoes release fluids with extremely high gas content and extreme variation in vent fluid chemistry.

(iii) In April/May 2004 the Lau Back Arc Basin along the East Lau Spreading Center (ELSC) was studied for the presence of hydrothermal activity. This research was followed up in 2004 and 2005 by having samples collected for the group by other cruises to this area. This research was funded by NSF's Ridge 2000 program under two separate proposals. It is part of an effort to develop an Integrated Study Site on the ELSC. The ELSC has the most striking and pronounced gradients in fundamental geophysical properties of any similar length of spreading axis on the globe. This makes the ELSC a particularly exciting place to study the interplay between magmatic and hydrothermal processes. This research has documented the extent and nature of hydrothermal activity along the ELSC, demonstrating that hydrothermal plume incidence vs. spreading rate on the ELSC exceeds that on mid-ocean ridges.

(iv) In November 2004, a paper was published that made an estimate of the global flux of carbon dioxide from the mid-ocean ridges. Among natural sources of CO_2 to the ocean, the MORs may be the largest source, although the flux of CO_2 from the submarine arcs and backarcs is not well constrained. An interesting implication of this research is that most of the CO_2 from submarine volcanoes must be emitted prior to eruption, not during or after. It would seem therefore that one might predict eruptions in advance by monitoring plumes above the MORs for emissions of CO_2.

2. (i) JISAO scientists are working with a large cast of investigators from the University of Washington and several other institutions on experiments to link seismic activity and hydrothermal processes (especially chemical and microbiological processes) along the Endeavour segment of the Juan de Fuca ridge and the Nootka fault zone adjacent to Vancouver island. Many different instruments are deployed at the same time in an inter-disciplinary approach to understand the links between physical, chemical, and biological processes in hydrothermal systems. This work, which is supported for 5 years (2001-2006) by the W. M. Keck Foundation, involves instrument development and experiments in the field. The JISAO component is focused on three time-series samplers for chemistry and microbiology that were deployed for a year and recovered during an Alvin submersible expedition in June of 2004. Those same instruments were re-deployed in September 2004, and will be recovered and deployed again in September 2005. JISAO scientists have participated in all of these expeditions.

(ii) JISAO scientists have pioneered the use of acoustic/satellite systems to enable two-way data transmission between the seafloor and shore-based laboratories. The NeMO-Net project is the first to return data via acoustic modem and satellite from a deep-sea site. This system has been working since 1999, and data are displayed in near real-time on the internet (http://www.pmel.noaa.gov/vents/nemo/realtime/index.html). Two-way communication allows direct modification of a seafloor sensing and sampling instrument, so that the sampling rate can be changed, special routines initiated, or immediate return of sensor data requested. Sensors include temperature and pH, with the addition in 2004 of a redox (Eh) sensor. Recovered filters and water samples allow extensive chemical analysis to detect changes related to volcanic activity or long-term evolution. In 2005, the interactive sampler was recovered, leaving only a bottom pressure recorder to detect inflation or deflation of this active volcano. The interactive sampler will be re-installed in 2006 if funding allows. The NOAA Vents program funds this work, with additional funding from NOAA West Coast and Polar Regions Undersea Research Center.

(iii) An *in situ* technique for iron analysis in the oceans has been developed. It is capable of measuring Fe at the very low levels typically

found in the surface ocean and the high levels found near shallow volcanoes along the Mariana Arc. The FOCI program has funded this project. The test bed for this instrument is the Gulf of Alaska, where the instrument will be deployed in August 2005 and recovered three weeks later. It is currently thought that iron might regulate plankton growth in the Gulf of Alaska and thus is an important cog in the Alaskan fishery ecosystem. These real time measurements will allow the researchers to better understand these ecosystems. In addition, this instrument will allow the group to monitor iron in plumes at other submarine volcanoes

3. (i) A unique sampling tool has been developed by JISAO scientist D. Butterfield that can take clean water samples and concentrate microbes on filters from the same location, while recording the temperature of the vent fluid in order to control sample quality. This sampler has been used extensively since 1998 to collect an unprecedented suite of samples that are being analyzed for their chemical and microbial content. Results have been published in a series of papers. A significant innovation includes the addition of an in-situ preservative for the extremely short-lived RNA molecule to reveal the true in-situ activity of hydrothermal microbes. This sampler has been used in support of this research goal throughout the NE Pacific and in global exploration of volcanic arcs. Research activities to support this goal have been sponsored by the PMEL Vents Program, Washington Sea Grant, NOAA West Coast and Polar Regions Undersea Research Center, the W.M. Keck Foundation, and the National Science Foundation. UW Oceanography graduate student Andrew Opatkiewicz is applying innovative methods of DNA analysis to samples collected from volcanic arcs and the Juan de Fuca ridge.

PROJECT:

Ocean Carbon and Climate Change Program: Research Support

PIS:

NOAA: Richard Feely

PERSONNEL:

UW: C. Cosca, F. Menzia

NOAA: Chris Sabine

TASK:

II

NOAA PRIMARY CONTACT:

Office of Climate Observations, Mike Johnson, Program Manager,

NOAA GOALS:

1. Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

The PMEL/JISAO Ocean Carbon and Climate Change Program (OCCCP) conducts research on the sources and sinks and biogeochemical impacts of carbon dioxide in the oceans (Feely and Wanninkhof, 2005). Atmospheric and oceanic carbon dioxide data are collected on cruises onboard NOAA vessels and from the TAO moorings. Modeling studies employing these data enhance the understanding of the ocean's role in the global carbon cycle and the important feedback mechanisms that will affect future climate changes. The following summarizes several of the OCCCP's successes, including promising developments in new research.

OBJECTIVES:

1. To contribute to our scientific understanding of carbon sources and sinks in the oceans.
2. To foster the use of chemical and hydrographic data information for modeling efforts
3. To contribute to graduate education at the University of Washington

ACCOMPLISHMENTS:

1. Determining the effects of the Pacific Decadal Oscillation on seawater pCO_2 in the equatorial Pacific. The equatorial Pacific Ocean is one of the most important yet highly variable oceanic source areas for atmospheric carbon dioxide (CO_2The group used the partial pressure of CO_2 (PCO_2), measured in surface waters from 1979 through early 2004, to examine the effect of the Pacific Decadal Oscillation phase shifts, which occurred in 1889-90 and 1997-98, on the equatorial Pacific CO_2 chemistry. As part of continuing effort to understand decadal changes in the carbon fluxes of the equatorial Pacific, the group developed seasonal and interannual fCO_2-SST relationships from shipboard data that were applied to high-resolution temperature fields deduced from satellite data to obtain high-resolution large-scale estimates of the regional fluxes. The data were gathered on board research ships from November 1981 through June 2004. The results indicated a strong interannual (ENSO) and weaker seasonal variability. There is also a slight increase (~27%) in the out-gassing flux of CO_2 after the 1997–1998 PDO mode shift. Most of this increase is due to increase in wind speeds after the spring of 1998 and are coincident with the recent rebound of the shallow water meridional overturning circulation in the tropical and subtropical Pacific after the PDO shift.

2. Distributing ocean carbon data to the oceanographic community. The OCCCP group has developed a WWW-based access for hydrographic and carbon data. This resource has been used by the modeling community to verify their carbon system biogeochemical process models for the oceans. The WWW site is supported by a live access server that provides both data access and graphical outputs. All the data and graphics can be found at the following WWW site: http://www.pmel.noaa.gov/co2/co2-home.html

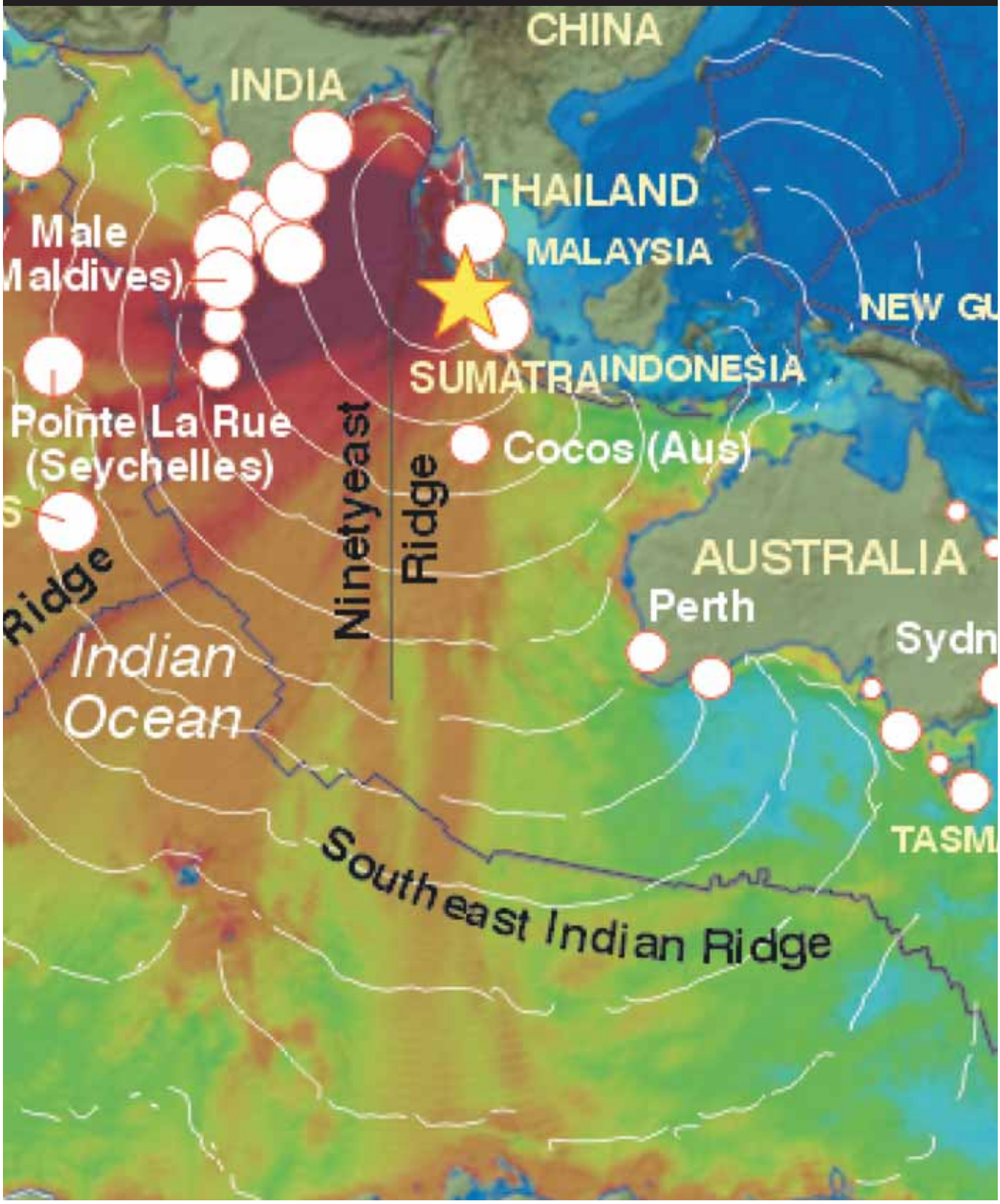
   Integrating historical PMEL carbon data with other data sets. The OCCCP group has

formed a partnership with CDIAC to provide data products from the Repeat Hydrography CO_2/Tracer Program and the WOCE/JGOFS/OACES Global CO_2 Survey. These products can be found at: http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm

3. Hosting North Pacific Climate Variability Session at the PICES Annual Meeting. The OCCCP Group hosted a special session on the variability of the North Pacific carbon system at the PICES Annual Meeting in Honolulu in October. The focus of the session was on an overall picture of North Pacific variability that draws together all of these individual lines of evidence and looks for coherent patterns that may help us understand the regional significance of this variability and the possible mechanisms controlling the observed spatial and temporal patterns. The session was designed to bring together relevant data sets for re-analysis with a view toward the larger picture. This data synthesis will be further enhanced by a simultaneous examination of North Pacific variability in a variety of climate model runs. University of Washington scientists directly contributed to and benefited from the special session.

JISAO Research Projects

COASTAL OCEANOGRAPHY



PROJECT:
Estuaries Research Program

PI:
UW: Vasily Titov,
NOAA: Frank Gonzalez

PERSONNEL:
UW: D. Arcas, C. Chamberlin, J.Newman, A.Venturato,
NOAA: E. Bernard, M. Eble, H. Mofjeld

TASK:
II

NOAA PRIMARY CONTACT:
Pacific Marine Environmental Laboratory

NOAA GOAL:
3. Serve Society's Needs for Weather and Water Information

The Estuaries Research Programs works with NOAA's National Center for Tsunami Research (NCTR) which is focused on improving the understanding of tsunami dynamics and the development of applications that will reduce the loss of life and property. Currently, the primary goals of NCTR are in direct support of a major expansion and acceleration of the NOAA Tsunami Program, in the wake of the 26 December 2004 Indian Ocean tsunami disaster. Shortly after this catastrophic event, President Bush called for action "… to improve tsunami protection for the United States … " by expanding U.S. capabilities in " … emergency warning systems …" In response, NCTR is accelerating research and development of the operational NOAA Tsunami Forecast System and expanding the geographical coverage of this forecast system to include the development of site-specific forecast models for 74 major U.S. population centers along Pacific, Caribbean, Atlantic and Gulf coasts.

In a broader context, NOAA bears national responsibility to address issues of public safety and economic cost associated with extreme weather and ocean hazards, including tsunamis, as reflected in the NOAA Mission Goals and Objectives outlined in *New Priorities for the 21st Century: NOAA's Strategic Plan* (http://www.spo.noaa.gov/). NOAA thus organized and leads the U.S. National Tsunami Hazard Mitigation Program (NTHMP), a Federal/ State collaborative partnership of NOAA, USGS, FEMA, NSF and the Emergency Management and Geotechnical agencies of U.S. coastal states. NCTR research and development is aimed at achieving tsunami-related goals of NOAA, including the specific objective to "Increase Lead Time and Accuracy for Weather and Water Forecasts." The PMEL/JISAO Estuaries Program works with NCTR to accomplish the following objectives:

OBJECTIVES:

1. To improve tsunami forecasts and warnings. The NCTR has developed and is implementing tsunami-forecasting tools for NOAA Tsunami Warning Centers (TWC). The methodology integrates two PMEL technologies – tsunami modeling and tsunameter measurements -- to provide real-time forecasts for warning guidance. This ongoing R&D in Tsunami Forecasting is being expanded and accelerated.
2. To improve tsunami hazard assessment methodology. R&D conducted by the NCTR to improve our understanding of tsunami dynamics is exploited to improve development of community-specific inundation maps that describe the potential hazard. These maps are essential tools for State Emergency Management and Geotechnical officials responsible for hazard mitigation, education, and disaster planning and response. The Federal Emergency Management Agency (FEMA) requires a probabilistic version of inundation mapping technology for development of Federal Rate Insurance Maps (FIRMs), used for actuarial purposes. Such probabilistic products would, of course, would be of great value for Emergency Management purposes, as well.

ACCOMPLISHMENTS

1. (i) Verification of Tsunami Forecast Methodology. Verification of the value of this methodology was achieved by forecasts produced during two events that threatened U.S. coastal communities:
   - *17 November 2003 Rat Island Tsunami*. A tsunami forecast was developed in near real-time by a PMEL scientist that produced an

extremely accurate match of the forecast and the subsequent measurement of the tsunami time series at Hilo, Hawaii.

- *14 June 2005 Eureka Tsunami.* Cancellation of a tsunami warning occurred shortly after a tsunameter measurement off Oregon verified a real-time forecast, posted to the WWW by a PMEL scientist, that the tsunami amplitude would be only 1 cm.

(ii) DART Project Scientific Support. Accurate and reliable deep-ocean and coastal tsunami measurement networks are crucial to the success the development of tsunami forecasting capabilities. The NCTR continues to provide scientific support for PMEL's Project DART (Deep-ocean Assessment and Reporting of Tsunamis) which has developed a tsunameter measurement system and established a deep-ocean network that provides tsunami data in real-time. Operational responsibility for the tsunameter network has being transferred to the NOAA National Data Buoy Center, and the NCTR will continue to support NDBC efforts to improve the quality and reliability of the network. The NCTR also provides scientific support for NOAA efforts to improve the tsunami measurement and reporting capabilities of the coastal tide gage network maintained by the NOAA National Ocean Service.

- *DART Network Optimization Workshop.* Twenty NOAA, USGS and academic scientists were brought together on 6 July 2005 to develop an optimal design strategy for a planned network of 39 DART stations in the Pacific, Caribbean, Atlantic and Gulf. A preliminary conceptual design was established, and a report is in preparation.
- *Gold Medal Award.* PMEL and NDBC were awarded a Gold Medal, the highest honor given by the Department of Commerce, for the development and successful transfer to operations of " … a new moored buoy system, developed by PMEL, to provide accurate and timely warning information for tsunamis."

2. Development of Probabilistic Tsunami Hazard Assessment (PTHA) methodology. A major, interagency effort by scientists from NOAA, USGS, U. Southern California and the Middle East Technical University was completed -- the Seaside, Oregon Tsunami Pilot Study and a report is now in review. This study developed a Probabilistic Tsunami Hazard Assessment (PTHA) methodology that included: quantitative probabilistic modeling of earthquake tsunami sources in the Cascadia, the Alaska-Aleutian, and the Peru-Chile Subduction Zones; paleotsunami deposit mapping and interpretation; numerical modeling to generate a tsunami inundation database; development and application of a probabilistic method to compute the distributions of 0.01 and 0.002 annual rates of occurrence (100- and 500-year distributions); analyses and application of various tsunami impact indices to generalize the concept of hazard zones; and preliminary recommendations to guide future Federal Insurance Rate Map (FIRM) development by FEMA.

APPENDICES

Appendix 1

JISAO Senior Fellows

UNIVERSITY OF WASHINGTON

Aagaard, Knut., Professor, Oceanography, Principal Oceanographer, Applied Physics Lab (APL)

Battisti, David S., Professor, Atmospheric Sciences, Asst. Vice Provost and Director, Earth Initiative

Bretherton, Chris, Professor, Atmospheric Sciences and Applied Mathematics

Cannon, Glenn A., Affiliate Professor, Oceanography

Charlson, Robert J, Professor Emeritus, Atmospheric Sciences

Covert, David S., Research Professor, Atmospheric Sciences

Emerson, Steven R., Professor, Oceanography

Eriksen, Charles C., Professor, Oceanography

Fleagle, Robert G., Professor Emeritus, Atmospheric Sciences

Fu, Qiang, Associate Professor, Atmospheric Sciences

Gammon, Richard H., Professor, Oceanography and Chemistry

Hartmann, Dennis L, Professor and Chair, Atmospheric Sciences

Jaegle, Lyatt, (JISAO Fellow), Assistant Professor, Atmospheric Sciences

Jaffe, Dan, Professor, Interdisciplinary Arts & Sciences, Adjunct Professor, Atmospheric Sciences

Lettenmaier, Dennis P., Professor, Civil and Environmental Engineering

McDuff, Russell, Director and Professor, Oceanography

Miles, Edward L., Professor, School of Marine Affairs

Murray, James W., Professor, Oceanography

Quay, Paul D., Professor, Oceanography

Rhines, Peter B., Professor, Oceanography

Thompson, LuAnne, Associate Professor, Oceanography

Untersteiner, Norbert , Professor Emeritus, Atmospheric Sciences

Wallace, J. Michael , Professor, Atmospheric Sciences, Director, JISAO

NOAA PACIFIC MARINE ENVIRONMENTAL LAB (PMEL)

Baker, Ed, Supervisory Oceanographer, Ocean Environment Research Division,
Affiliate Professor, Oceanography

Bates, Timothy S., Research Chemist, Ocean Climate Research Division,
Affiliate Assoc Professor, Atmospheric Sciences

Bullister, John, (JISAO Fellow) Oceanographer, Ocean Climate Research Division,
Affiliate Assoc Prof, Oceanography

Cronin, Meghan, Oceanographer, Ocean Climate Research Division,
Affiliate Associate Professor, Oceanography

Feely, Richard A., Supervisory Oceanographer, Ocean Climate Research Division,
Affiliate Professor, Oceanography

Harrison, D.E., Oceanographer, Ocean Climate Research Division,
Affiliate Professor, Oceanography & Atmos Sciences

Johnson, Gregory C., Oceanographer, Ocean Climate Research Division,
Affiliate Professor, Oceanography

Kessler, William S., Oceanographer, Ocean Climate Research Division,
Affiliate Professor, Oceanography

McPhaden, Michael J., Senior Research Scientist, Ocean Climate Research Division,
Affiliate Professor, Oceanography

Mofjeld, Harold O., Oceanographer, Ocean Environment Research Division,
Affiliate Professor, Oceanography

Moore, Dennis W., Leader, Ocean Climate Research Division,
Affiliate Professor, Oceanography

Overland, James E., Division Leader, Coastal and Arctic Research Division,
Affiliate Professor, Atmospheric Sciences

Quinn, Patricia K., Research Chemist, Ocean Climate Research Division

Sabine, Christopher, Oceanographer, Ocean Climate Research Division,
Affiliate Assistant Professor, Oceanography

Stabeno, Phyllis, Supervisory Oceanographer, Ocean Climate Research Division

Appendix 2

Task I 2004-2005 Visiting Scientists

JULY 15, 2004

Joseph Prospero, Professor of Marine and Atmospheric Chemistry at the Rosenstiel school and Director of CIMAS. "Mineral Dust Transport to the North Atlantic and The North Pacific Oceans: Temporal Variability and the Link to Climate."

AUGUST 9, 2004

Brian Hoskins, Professor, Department of Meteorology, University of Reading, UK. "Some recent extreme seasons in Europe winter storm-tracks in both hemispheres blocking in both hemispheres."

AUGUST 25

Willem Sijp, Ph.D. student, UNSW Oceanography and Climate. "The role of Drake Passage in the thermohaline circulation."

OCTOBER 15, 2004

Franco Molteni, Senior Scientist, Physics of Weather and Climate Group, The Abdus Salam International Centre for Theoretical Physics, Italy. "SPEEDY", a stripped down atmospheric model, in decadal climate variability.

NOVEMBER 1, 2004

Sandy Tudhope, Senior Lecturer at the University of Edinburgh. Visiting Scientist for three years.

DECEMBER 3, 2004

David Thompson, Assistant Professor, Department of Atmospheric Science, Colorado State University. "The impact of the stratosphere on troposheric climate."

FEBRUARY 28, 2005

Sumant Nigam, Professor of Meteorology and Earth System Science at the University of Maryland. "Warm-season hydroclimate variability over the Great Plains in observations, reanalysis, and atmospheric model simulations."

MARCH 4, 2005

Carl Wunsch, Professor, Department of Earth, Atmospheric, and Planetary Sciences, MIT. "Abrupt Climate Change: A Different Interpretation."

Appendix 3

JISAO Employees Supported By Task II Projects

NAME	TITLE
A'hearn, Patrick N.	Research Consultant
Alvarez-Flores, Carlos	Research Associate
Arcas, Diego Rodriguez	Research Engineer
Bahl, Kimberly Y.	Research Consultant
Bond, Nicholas A	Meteorologist
Burger, Eugene F.	Research Consultant
Butterfield, David A.	Oceanographer
Callahan, Jonathan S.	Research Consultant
Chamberlin, Christophe	Research Engineer
Cheng, Wei	Research Scientist
Ciannelli, Lorenzo	Research Associate
Coffman, Derek J	Research Scientist
Cosca, Catherine	Research Scientist
Covert, Paul A.	Research Scientist
Denbo, Donald W.	Research Scientist
Dobbins, Elizabeth L	Research Scientist
Doherty, Sarah J.	Research Scientist
Dougherty, Daniel M	Research Consultant
Doyle, Miriam	Research Scientist
Fey, Curran W.	Research Consultant
Flosadottir, Agusta H.	Research Engineer
Hamilton, Drew C.	Oceanographer
Hermann, Albert J	Oceanographer
Jenkins, Antonio	Research Scientist
Johnson, James E.	Oceanographer
Kachel, Nancy B	Oceanographer
Ladd, Carol A	Research Scientist
Lebon, Geoffrey T.	Research Scientist
Lee, Yong Woo	Research Associate
Marianna, Cara J.	Fiscal Specialist
Mazur, Michael M.	Research Associate
Mc Carty, Marguerite E	Research Scientist
Mc Clurg, Dai C.	Research Scientist
Mchugh, Kevin Thomas	Research Scientist
Mclean, Joseph M.	Research Consultant
Menzia, Frederick	Research Scientist
Merati, Nazila	Research Scientist
Miller, Theresa L.	Research Scientist
Moon, Sookmi	Research Engineer
Moore, Christopher W.	Research Scientist
Mordy, Calvin W	Oceanographer
Mueter, Franz J.	Research Associate

NAME	TITLE
Noor, Sonya M.	Research Consultant
O'Brien, Kevin	Research Scientist
Parada Veliz, Carolina	Research Associate
Proctor, Peter D.	Research Scientist
Resing, Joseph A.	Research Scientist
Righi, Dylan D.	Research Scientist
Rodionov, Sergei	Research Scientist
Roe, Kevin K	Research Scientist
Sawatzky, Trisha	Research Consultant
Schulz, Kristen	Research Engineer
Serra, Yolande L.	Research Consultant
Sorvik, Paul	Research Engineer
Spillane, Michael C	Research Scientist
Steed, Richard	Research Scientist
Steele, T	Tech Writer
Stratton, Linda	Research Scientist
Sullivan, Margaret E.	Research Scientist
Titov, Vassilii V	Research Scientist
Venturato, Angie J.	Research Scientist
Wang, Muyin	Meteorologist
Wood, Kevin R.	Research Scientist
Zhang, Dongxiao	Research Scientist
Zhu, Hui Willa	Research Scientist
Zimmerman, David K.	Research Engineer

Appendix 4

Task III — UW Principal Investigators and Projects

PI NAME	ACADEMIC UNIT	TITLE OF PROJECT	FUNDING
Bretherton	Atmospheric Sciences	Climate Process Team on Low-Latitude Cloud Feedbacks on Climate Sensitivity	$108,180
Covert	Atmospheric Sciences	Aerosol Optical Properties: Measurement of Light Scattering & Absorption on NOAA Research Aircraft & Vessel of Understanding Radiative Transfer	$151,084
Covert	Atmospheric Sciences	Aerosol Optical Properties: Measurement of Light Scattering & Absorption on NOAA Research Aircraft & Vessel of Understanding Radiative Transfer	$101,588
Dickhoff	Aquatic & Fisheries Sciences	Growth & Development of Salmon	$44,596
Essington	Aquatic & Fisheries Sciences	Atka Mackerel Food Habit Project	$68,239
Hilborn	Aquatic & Fisheries Sciences	Grad Student Stipend for Stock Assessment Training	$47,000
Horne	Aquatic & Fisheries Sciences	Fisheries Acoustic Research	$138,345
Howe	Oceanography	Analyze Ocean Ambient Sound Data	$50,000
Layton	Evans School of Public Affairs	Estimating Economic Impact of Stellar Sea Lion Conservation Area: Developing & Applying New Methods for Evaluating Spatially Complex Area Closures	$17,079
Lettenmaier	Civil & Environ Engineering	Development of Hydrologic Nowcast & Forecast Products Using Land Data Assimilation	$110,000
Lettenmaier	Civil & Environ Engineering	Experimental Western US Hydrologic Forecasting Systems	$100,000
Lindsay	Applied Physics Lab	Monitoring Ice Thickness in the Western Arctic Ocean	$63,500
Mass	Atmospheric Sciences	Regional Weather Analysis & Prediction	$124,101
Miles	Marine Affairs	Downscaling PNW Climate	$75,000
Miles	Marine Affairs	Center for Science in the Earth System	$885,000
Miller	Aquatic & Fisheries Sciences	Marine Biological Interactions in the N Pacific-Fish Interactions	$331,499
Naish	Aquatic & Fisheries Sciences	Molecular Genetics of Pacific Salmon	$26,413
Naish	Aquatic & Fisheries Sciences	Molecular Genetics of Pacific Salmon	$103,238
Percival	Applied Physics Lab	Wavelet Analysis of Bering Sea Temperature Time Series	$30,000
Quay	Oceanography	Surface Ocean 13C/12C Measurements: A Tracer of Anthropogenic CO2 Uptake	$160,848
Quay	Oceanography	Carbon Isotope Constraints on Ocean GCM Simulations of Anthropogenic CO2 Uptake	$102,649

PI NAME	ACADEMIC UNIT	TITLE OF PROJECT	FUNDING
Rhines	Oceanography	Oceanic Observations of Climate Change in the Arctic Subpolar Zone	$365,600
Rigor	Applied Physics Lab	Monitoring the Eurasian Basin of the Arctic Ocean	$60,000
Riser	Oceanography	Charter Research Vessels for Deployment of US ARGO Floats in the S Pacific	$1,198,319
Riser	Oceanography	The ARGO Project: Global Ocean Observations for Understanding Climate Variability	$2,715,299
Sarachik	Atmospheric Sciences	Simulating ARGO Measurement in an Ocean GCM	$60,000
Sarachik	Atmospheric Sciences	Center for Science in the Earth System	$610,000
Schweiger	Applied Physics Lab	Correction of Systematic Error in the TOVS Radiance	$65,000

Appendix 5

JISAO Projects by Task

TASK	PI	AWARD $	PROJECT TITLE
1	Wallace	$155,100	Core
1	Wallace	$45,000	Core
1	Wallace	$5,000	Second International Conference on Climate Impacts Assessment
1	Wallace	$10,000	Special Presidential Award to Research Scientist Nathan Mantua
2	Wallace	$10,730	Biophysical Models of Pollack Recruitment Processes in the Western Gulf of Alaska
2	Wallace	$20,910	Fisheries-Oceanography Coordinated Investigations (FOCI) Research Support
2	Wallace	$1,333,677	Fisheries-Oceanography Coordinated Investigations: Research Support
2	Wallace	$43,898	Forage Fishes in the Western Gulf of Alaska: Variation in Productivity
2	Wallace	$66,763	Forage Fishes in the Western Gulf of Alaska: Variation in Productivity
2	Wallace	$29,024	Gulf of Alaska Spring Ichthyoplanktin Interannual Trends
2	Wallace	$65,969	Variability in the Spatial Distribution of Demersal Species Along the West Coast of North America in Response to Climate Changes and Fishing
2	Wallace	$304,640	NOAA Fisheries Research Cruise
2	Wallace	$379,093	Estuaries Research Program: Research Support
2	Wallace	$300,070	Submarine Hydrothermal Venting Program: Research Support
2	Wallace	$26,314	Supplemental funding for NOAA Office of Ocean Exploration to the Marianas Volcanic Arc
2	Wallace	$5,318	Supplies/Services Support
2	Wallace	$75,000	Supplies/Services Support
2	Wallace	$75,000	Travel Support
2	Wallace	$32,899	Intraseasonal Ocean Response to Atmospheric Forcing Program: Research Support
2	Wallace	$14,937	Moored Tropical Rainfall Analysis Program: Research Support
2	Wallace	$61,867	Observing Systems Research Studies Program (Graduate Students)
2	Wallace	$304,527	Observing Systems Research Studies Program: Research Support
2	Wallace	$47,256	Pacific Ocean Circulation Program
2	Wallace	$99,073	Tropical Atlantic Ocean Circulation Program: Research Support
2	Wallace	$706,367	Tropical Ocean Atmosphere Program; Research Support

TASK	PI	AWARD $	PROJECT TITLE
2	Wallace	$386,832	Atmospheric Chemistry Program: Research Support
2	Wallace	$148,845	Chlorofluorocarbon Tracer Program: Research Support
2	Wallace	$147,132	Marine Carbon Program: Research Support
2	Wallace	$13,608	Supplemental Funding for Kristen Schultz under the Atmospheric Chemistry Research Studies Program
3	Bretherton	$108,180	Climate Process Team on Low-Latitude Cloud Feedbacks on Climate Sensitivity
3	Covert	$151,084	Aerosol Optical Properties: Measurement of Light Scattering & Absorption on NOAA Research Aircraft & Vessel of Understanding Radiative Transfer
3	Covert	$101,588	Aerosol Optical Properties: Measurement of Light Scattering & Absorption on NOAA Research Aircraft & Vessel of Understanding Radiative Transfer
3	Dickhoff	$44,596	Growth & Development of Salmon
3	Essington	$68,239	Atka Mackerel Food Habit Project
3	Hilborn	$47,000	Grad Student Stipend for Stock Assessment Training
3	Horne	$138,345	Fisheries Acoustic Research
3	Howe	$50,000	Analyze Ocean Ambient Sound Data
3	Layton	$17,079	Estimating the Economic Impact of Stellar Sea Lion Conservation Area: Developing & Applying New Methods for Evaluating Spatially Complex Area Closures
3	Lettenmaier	$110,000	Development of Hydrologic Nowcast & Forecast Products Using Land Data Assimilation
3	Lettenmaier	$100,000	Experimental Western US Hydrologic Forecasting Systems
3	Lindsay	$63,500	Monitoring Ice Thickness in the Western Arctic Ocean
3	Mass	$124,101	Regional Weather Analysis & Prediction
3	Miles	$75,000	Downscaling PNW Climate
3	Miles	$885,000	Center for Science in the Earth System
3	Miller	$331,499	Marine Biological Interactions in the N Pacific-Fish Interactions
3	Naish	$26,413	Molecular Genetics of Pacific Salmon
3	Naish	$103,238	Molecular Genetics of Pacific Salmon
3	Percival	$30,000	Wavelet Analysis of Bering Sea Temperature Time Series
3	Quay	$160,848	Surface Ocean 13C/12C Measurements: A Tracer of Anthropogenic CO2 Uptake
3	Quay	$102,649	Carbon Isotope Constraints on Ocean GCM Simulations of Anthropogenic CO2 Uptake

Appendix 5 continued

TASK	PI	AWARD $	PROJECT TITLE
3	Rhines/Erickson	$365,600	Oceanic Observations of Climate Change in the Arctic Subpolar Zone
3	Rigor	$60,000	Monitoring the Eurasian Basin of the Arctic Ocean
3	Riser	$1,198,319	Charter Research Vessels for Deployment of US ARGO Floats in the S Pacific
3	Riser	$2,715,299	The ARGO Project: Global Ocean Observations for Understanding Climate Variability
3	Sarachik	$60,000	Simulating ARGO Measurement in an Ocean GCM
3	Sarachik	$610,000	Center for Science in the Earth System
3	Schweiger	$65,000	Correction of Systematic Error in the TOVS Radiance

Appendix 6

Publication Count

	JOINT INST LEAD AUTHOR				NOAA LEAD AUTHOR				OTHER LEAD AUTHOR				
	FY 01	FY 02	FY 03	**FY 04**	FY 01	FY 02	FY 03	**FY 04**	FY 01	FY 02	FY 03	FY 04	TOTAL
Peer-reviewed	27	43	33	**73**	21	35	61	**22**	*	*	*	**90**	405
Non peer-reviewed	23	30	15	**9**	16	10	21	**0**	*	*	*	**6**	130
Totals	50	73	48	**82**	37	45	82	**22**	*	*	*	**96**	**535**

*data not available

Appendix 7

Personnel

Category	Number	B.S.	M.S.	Ph.D.
Research Scientist	62	6	15	41
Visiting Scientist	8	0	1	7
Postdoctoral Fellow**	7	0	0	7
Research Support Staff	3	3	0	0
Administrative	0	0	0	0
Total (> or = 50%)	**80**	**9**	**16**	**55**
Undergraduate Students	6			
Graduate Students	26	15	11	0
Employees receiving less than 50% NOAA support)	99			
Located at Lab	PMEL: 6, Atmos Sci: 18, Fisheries: 2			
Obtained NOAA employment within the last year	4			

**9 additional Post-Docs received less than 50% support from JISAO

Appendix 8

JISAO Graduate Students

GRAD STUDENT NAME	ACADEMIC DEPARTMENT	DEGREE	PHD SUPERVISOR
Agostini, Vera	School of Aquatic & Fisheries Sci	Ph.D.	Robert Francis
A'mar, Z Teresa	Quant Ecol Res Mangmnt	Ph.D.	Andre Punt
Ball, Joseph Andre	Civil & Environmental Engineering	Ph.D.	Rick Palmer
Bamasoud, Abdullah S.	Oceanography	Ph.D.	Craig Lee
Burgos, Julian	School of Aquatic & Fisheries Sci	Ph.D.	John Horne
Carson, Mark L.	Oceanography	M.S.	Ed Harrison
Chiodi, Andrew M.	Oceanography	M.S.	Ed Harrison
Garvert, Matthew F.	Atmos Sci	Ph.D.	Cliff Mass
Grimit, Eric	Atmos Sci	Ph.D.	Cliff Mass
Kinzey, Douglas	School of Aquatic & Fisheries Sci	Ph.D.	Andre Punt
Littell, Jeremy	College of Forest Resources	Ph.D.	David Peterson
Mccormick, Hafen S.	Atmos Sci	M.S.	Cliff Mass
Miller, Timothy	School of Aquatic & Fisheries Sci	Ph.D.	John Skalski
Morlock, Summer M.	School of Marine Affairs	M.S.	Ed Miles
Opatkiewicz, Andrew D.	Oceanography	M.S.	Evelyn Lessard
Ortiz, Ivonne	School of Aquatic & Fisheries Sci	Ph.D.	Bob Francis
Quadralli, Roberta	Atmos Sci	Ph.D.	J. Michael Wallace
Roberts, William H.	Atmos Sci	Ph.D.	David Battisti
Steinberger, Andrea	Oceanography	M.S.	Paul Quay
Takahashi, Ken	Atmos Sci	Ph.D.	David Battisiti
Trask, Richard Blake	School of Marine Affairs	M.S.	Ed Miles
Van Rheenen, Nathan	Civil & Environmental Engineering	Ph.D.	Rick Palmer
Wade, Rachel H.	Oceanography	M.S.	
Zahn, Patrick H.	Atmos Sci	M.S.	Cliff Mass
Zhang, Xuebin	Oceanography	Ph.D.	Mike McPhaden
Zhu, Chunmei	Civil & Environmental Engineering	Ph.D.	Dennis Lettenmaier

Appendix 9

Postdoctoral Fellows

Alvarez-Flores, Carlos**

Bertschi, Isaac T

Boldt, Jennifer

Ciannelli, Lorenzo**

Dirren, Sebastien**

Fueglistaler, Stephan**

Hastings, Meredith

Ito, Taka

Jurado-Molina, Jesus

Lorenz, David**

Mazur, Michael

Mueter, Franz J**

Parada-Velez, Carolina

Rice, Andrew

Rodrigues, Regina R.

Shevenell, Amelia**

***received less than 50% support from JISAO*

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Appendix 10

JISAO Awards And Honors

2005

Gold Medal for DART Project. PMEL was awarded a Gold Medal, the highest honor given by the Department of Commerce, for the development and successful transfer to operations of a new moored buoy system, developed by PMEL, to provide accurate and timely warning information for tsunamis. http://www.pmel.noaa.gov/tsunami/news_goldmedal.htm

Lettenmaier, Dennis, Senior Fellow, received the Walter Orr Roberts Lecture award at the AMS January Meeting.

Rhines, Peter, Senior Fellow, received the Haurwitz Lecturer award at the AMS Meeting.

Rhines, Peter, Senior Fellow, received the Houghton Lecturer, MIT.

2004

Bates, Timothy, Senior Fellow, received the NOAA Administrator's Award i*n recognition of leadership in national and international atmospheric chemistry programs.*

Bates, Timothy, Senior Fellow, received NOAA Administrator's Award.

Battisti, David named the Thompson Lecturer at NCAR.

Emerson, Steve, Senior Fellow, elected Fellow of American Geophysical Union.

Feely, Richard, Senior Fellow, and Christopher L. Sabine, Senior Fellows, were lead author and co-author (with T. Takahashi and R. Wannikov) on the paper "Uptake and storage of carbon dioxide in the oceans". Oceanography 14(4), 18-32; 2002 Outstanding Paper Award.

The American Geophysical Union has instituted the **James R. Holton** Award for outstanding young scientists. Holton was a JISAO Senior Fellow who died March 2004.

Johnson, Gregory, Fellow, received NOAA/PMEL Outstanding Scientific Papers award.

McPhaden, Michael, Senior Fellow, named one of the University of Colorado's Distinguished Lecturers.

McPhaden, Michael, Senior Fellow, received the Presidential Rank Award for Meritorious Federal Service.

McPhaden, Michael, Senior Fellow, listed in Thomson ISI Highly Cited Researchers in Geosciences

Miles, Edward, Senior Fellow, Director of the JISAO Climate Impacts Group, elected a member of the National Academy of Sciences.

Murray, James, Senior Fellow, acknowledged by ISI as Highly Cited.

O'Brien, Kevin, research scientist, received a letter of accommodation from NDBC Lab Director Paul Moersdorf for work done in the lab.

Ortiz, **Yvonne,** a collaborator on JISAO Task III projects, received an award for the best poster at the International Symposium for Quantitative Ecosystem Indicators in Paris, France, March 31-April 3, 2004.

Roe, Kevin, research scientist, received a letter of accommodation from the NDBC Lab Director Paul Moersdorf for work done while visiting the lab.

Vecchi, Gabriel, research scientist, received the PECASE Award Presidential Early Career Award for Scientists and Engineers for his fundamental contributions concerning the roles of subseasonal variability on the onset and termination of El Niño and on Indian Monsoon rainfall.

Untersteiner, Norbert, Senior Fellow, elected Fellow of the AAAS.

Zhang, Dongxiao, research scientist, awarded in 2004,-NOAA/OAR Outstanding Scientific Paper Award: McPhaden, M.J., and D. Zhang, 2002: Slowdown of the Meridional Overturning Circulation in the Upper Pacific Ocean. Nature, 415: 603-608.

Appendix 11

July 2004 – June 2005 JISAO Publications (Published or Submitted)

1 Aguilar-Islas, A.M., J.A. Resing, K.W. Bruland: Flow injection catalytically enhanced spectrophotometric detection of dissolved manganese in seawater with on-line preconcentration using a commercially available resin. *Limnology and Oceanography,* submitted.

2. A'mar, Z.T. and A.E. Punt: 2005. Minimum Stock Size Thresholds: How well can we detect whether stocks are below them? p. 00-00. In: G. Kruse, V.F. Gallucci, D.E. Hay, R.I. Perry, R.M. Peterman, T.C. Shirley, P.D. Spencer, B. Wilson, and D. Woodby [ed.]. In: *Proceedings of the 21st Lowell Wakefield Fisheries Symposium: Assessment and management of new and developed fisheries in data-limited situations*. Alaska Sea Grant College Program, University of Alaska Fairbanks, Fairbanks, AK

3. Andreadis, K.M., E.A. Clark, A. W. Wood, A. F. Hamlet, and D. P. Lettenmaier: (In press). 20th century drought in the conterminous United States. To appear in the *Journal of Hydrometeorology*.

4. Andersen, M.S., E. L. Miles, and D. L. Fluharty: 2004. A comparison of the incorporation of climate forecasts and other climate information by coastal managers in the Pacific Northwest between 1996 and 2003. In *conference proceedings for The Coastal Society 19th International Conference, Alexandria, Virginia: The Coastal Society.*

5. Bacastow, R.B., C.D. Keeling, T.J. Lueker, M. Wahlen, and W.G. Mook: The ^{13}C Suess effect in the world surface oceans and its implications for oceanic uptake of CO_2: analysis of observations at Bermuda, *Global Biogeochem. Cycles*, *10*, 335-346, 1996.

6. Bailey, D., P.B.Rhines and S.Hakkinen, 2005: Pathways and formation of North Atlantic Deep Water in a coupled ice-ocean model of the Arctic-North Atlantic Oceans. *Clim. Dynamics.,* in press.

7. Bates, T.S., P.K. Quinn, D.J. Coffman, J.E. Johnson, A. Middlebrook: The dominance of organic aerosols over the Gulf of Maine during NEAQS 2002. *Journal of Geophysical Research (Atmospheres),* submitted.

8. Bates, T.S., P.K.Quinn, D.J. Coffman, D.S. Covert, T.L.Miller, J.E. Johnson, G.R. Carmichael, S.A. Guazzotti, D.A. Sodeman, K.A. Prather, M. Rivera, L.M. Russell, and J.T. Merrill: (2004) Marine boundary layer dust and pollution transport associated with the passage of a frontal system over eastern Asia, *J. Geophys. Res.,* 109, D19, doi:10.1029/2003JD004094.

9. Bergstrom, R.W., P. Pilewskie, B. Schmid, J. Redemann, P. Russell, A. Hiragashi, T. Nakajima, **P.** Quinn**:** (2004) Spectral absorption of solar radiation by aerosols during ACE-Asia, *J. Geophys. Res.,* 109, D19S15, doi:10.1029/2003JD004467.

10. Bigler, B.S., D.W. Welch and J.H. Helle. 1996. A review of size trends among North Pacific salmon (Oncorhynchus spp.). Can. J. Fish Aquat. Sci. 53:455-465.

11. Bond, N.A., and C.F. Dierking: Wind profiler and research aircraft observations in Gastineau Channel during the Taku wind event of 18 October 2004. *Weather and Forecasting,* submitted.

12. Bond, N., and D. E. Harrison. (In review). U.S. winter weather anomalies with El Nino and negative Arctic oscillation: 2002-03 and before. Submitted to *Weather and Forecasting.*

13. Buck, C.S., W.M. Landing, and J.A. Resing: Aerosol iron and aluminum solubility in the northwest Pacific Ocean: results from the 2002 IOC cruise. *Geochemistry, Geophysics, Geosystems,* submitted.

14. Burger, E.F., J. Warren: A Secure, Low-cost Networked Continuation of Operations Standby System for the OAR Science Management System Proceedings: 21st International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, 85th AMS Annual Meeting, January 9-13, 2005, San Diego, CA.

15. Canning, D. J., and P. W. Mote: (In review). Climate impacts on the coasts of the Pacific Northwest. Chapter 9 in E.L. Miles, A. K. Snover and The Climate Impacts Group, Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest, Cambridge, Massachusetts: MIT Press.

16. Center for Science in the Earth System. 2004. Proposal to NOAA OGP: CDEP and RISA programs, April 1, 2005-March 31, 2010. Proposal to the NOAA Office of Global Programs for 2005-2010. Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, WA.

17. Chen, J., J. Avise, J. Vaughan, B. Lamb, C. F. Mass, E. P. Salathé, A. Guenther, C. Wiedinmyer, S. O'Neill, S. Ferguson, N. Larkin, and D. McKenzie. 2004. Impact of Climate Change on U.S. Air Quality Using Multi-scale Modeling with the MM5/SMOKE/CMAQ System. In proceedings for Symposium on Planning, Nowcasting, and Forecasting in the Urban Zone, Boston, Massachusetts: American Meteorological Society.

18. Cheng, W. and P.B.Rhines, 2003: Response of the overturning circulation to regional fresh water perturbations in the North Atlantic, Clim. Dyn., 22, 359-372

19. Channing, C. E., K. M. Gillis, D. A. Butterfield: Alteration and Mass Transfer at Axial, Low Temperature Diffuse Hydrothermal Sites. Geochimica et Cosmochimica Acta, submitted.

20. Ciannelli, L, B.W. Robson, R. C. Francis, K Aydin, and R.D. Brodeur. (In press). Boundaries of open marine ecosystems: an application to the Pribilof archipelago, southeast Bering Sea. To appear in Ecological Applications.

21. Climate Impacts Group. 2004. Overview of Climate Change Impacts in the U.S. Pacific Northwest. Background paper prepared for the West Coast Governors' Climate Change Initiative.

22. Cohen, S. J., R. de Loe, A. F. Hamlet, R. Herrington, L. Mortsch, and D. Shrubsole: 2004. Integrated and cumulative threats to water. Threats to Fresh Water Availability in Canada Environment Canada, NWRI Scientific Assessment Report Series No.3, Chapter 15, Burlington, Ontario: National Water Research Institute.

23. Cooper, D. W., K. E. Pearson, D. R. Gunderson: Annual Fecundity and an Indirect Estimate of Natural Mortality Rate for Reinhardtius hippoglossoides (Greenland Turbot or Greenland Halibut). Fishery Bulletin, submitted.

24. Cronin, M.F., N.A. Bond, C. Fairall, and R.A. Weller: 2004: Surface cold forcing in the East Pacific Stratus Deck/Cold Tongue/ITCZ Comp. Journal of Climate. Submitted.

25. Cuny, J., P.B.Rhines, J.Lazier,F.Schott, 2005: Convection above the Labrador Slope. J. Phys. Oceanogr. 35, 489-511.

26. Cuny, J., P.B. Rhines, R.Kwok, 2005: Davis Strait Fluxes, J.Phys. Oceanogr., Deep-Sea Res. 52, 519-542.

27. Curchitser, E.N., D.B. Haidvogel, A.J. Hermann, E.L. Dobbins, and T.M. Powell: Multi-scale modeling of the North Pacific Ocean I: Assessment and analysis of simulated basin-scale variability (1996-2003). Journal of Geophysical Research. Submitted.

28. de Gouw, J.A., A.M. Middlebrook, C. Warneke, P.D. Goldan, W.C. Kuster, J.M. Roberts, F.C. Fehsenfeld, D.R. Worsnop, M.R. Canagaratna, A.A.P. Pszenny, W.C. Keene, M. Marchewska, S.B. Bertman, and T.S. Bates: The budget of organic carbon in a polluted atmosphere: Results from the New England Air Quality Study in 2002, Journal of Geophysical Research, in press.

29. Doherty, Sarah J.; Quinn, Patricia K.; Jefferson, Anne; Carrico, Christian M.; Anderson, Theodore L., Hegg, Dean: A comparison and summary of aerosol optical properties as observed in situ from aircraft, ship, and land during ACE-Asia. Journal of Geophysical Research, 110 (D4), D04201, doi: 10.1029/2004JD004964.

30. Dettinger, M.D., D.S. Battisti, G.J. McCabe Jr., D.M. Bitz, and R.D. Garreaud: Inter-hemispheric effects of interannual and decadal ENSO-like climate variations on the Americas Inter-hemispheric Climate Linkages in the American and their Societal Effects, V. Markgraf, ed., Academic Press, 2000.

31. deYoung, B., R. Harris, J. Alheit, G. Beaugrand, N. J. Mantua, and L. Shannon. 2004. Detecting regime shifts in the ocean: Data considerations. Progress in Oceanography 60(2-4):143-164.

32. Elman, E, and D. L. Peterson. (In review). Regeneration and understory response to harvest in subalpine forests of the North Cascade Range, Washington. Submitted to the Journal of Ecosystems and Management.

33. Fagre, D. B., and D. L. Peterson. (In press). Modeling and monitoring ecosystem responses to climate change in three North American mountain ranges. In C. Körner and E. Spehn (eds.), Global Mountain Biodiversity: Changes and Threats. Springer-Verlag, Berlin.

34. Feely, R.A., and L.D. Talley (2005): CLIVAR/CO2 Repeat Hydrography Program Cruises reveal large-scale chemical changes in the North Atlantic. Eos, Trans. AGU [Submitted].

35. Feely, R., and R. Wanninkhof (2005): The global ocean carbon cycle: Inventories, sources and sinks. The State of the Ocean and the Ocean Observing System for Climate, Annual Report, Fiscal Year 2004, NOAA/OGP/Office of Climate Observation, Section 2.5, 42–56.

36. Feely, R.A., T. Takahashi, R. Wanninkhof, M.J. McPhaden and C.E. Cosca: Decadal variability of the air-sea CO2 fluxes in the Equatorial Pacific Ocean. Journal of Geophysical Research. Submitted.

37. Feely, R.A., T. Takahashi, R. Wanninkhof, M.J. McPhaden, C.E. Cosca, S.C. Sutherland, and M.-E. Carr (2005): Decadal variability of the air-sea CO2 fluxes in the equatorial Pacific Ocean. J. Geophys. Res. [Submitted].

38. Feely, R.A., R. Wanninkhof, C. Sabine, G. Johnson, M. Baringer, J. Bullister, C.W. Mordy, and J.-Z. Zhang (2005): Global repeat hydrographic/CO2/tracer surveys in support of CLIVAR and global carbon cycle objectives: Carbon inventories and fluxes. The State of the Ocean and the Ocean Observing System for Climate, Annual Report, Fiscal Year 2004, NOAA/OGP/Office of Climate Observation, Section 3.15a, 149–168.

39. Feely, R.A., R. Wanninkhof, C. Sabine, G. Johnson, M. Baringer, J. Bullister, C.W. Mordy, and J.-Z. Zhang (2005): 2005 Plans, Global repeat hydrographic/CO2/tracer syrveys in support of CLIVAR and global carbon cycle objectives: Carbon inventories and fluxes. The State of the Ocean and the Ocean Observing System for Climate, Annual Report, Fiscal Year 2004, NOAA/OGP/Office of Climate Observation, Section 3.14b, 298–300.

40. Fluharty, D. L. (In review). Humans in the Pacific Northwest. Chapter 3 in E.L. Miles, A. K. Snover and The Climate Impacts Group, *Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest*, Cambridge, Massachusetts: MIT Press.

41. Freitag, H.P.,T.A. Sawatzky, K.B. Ronnholm, M.J. McPhaden: Calibration procedures and instrumental accuracy estimates of next generation atlas water temperature and pressure measurements. *NOAA Technical Memo,* Submitted.

42. Gedalof, Z. M., D. L. Peterson, and N. J. Mantua: (In press). Atmospheric, climatic and ecological controls on extreme wildfire years in the northwestern United States. Submitted to *Ecological Applications*.

43. Gedalof, Z. M., D. L. Peterson, and N. J. Mantua: (In press). Columbia River flow and drought since 1750. Submitted to *Journal of the American Water Resources Association*.

44. Goes, J.I., H.R. Gomes, T. Saino, C.S. Wong, and C.W. Mordy:11/2/2004 Exploiting MODIS Data for Estimating Sea Surface Nitrate From Space. *Eos, Transactions, American Geophysical Union,* 85(44), 449, 2004.

45. Goodman, P.J., and E. Sarachik. (In review). Forced variability of North Atlantic deep water production in an ocean GCM. Submitted to the *Journal of Marine Research*.

46. González, F.I., E.N. Bernard, C. Meinig, M. Eble, H.O. Mofjeld, and S. Stalin (2005): The NTHMP tsunameter network. *Nat. Hazards*, 35(1), Special Issue, *U.S. National Tsunami Hazard Mitigation Program*, 25–39.

47. González, F.I., V.V. Titov, H.O. Mofjeld, A. Venturato, S. Simmons, R. Hansen, R. Combellick, R. Eisner, D. Hoirup, B. Yanagi, S. Yong, M. Darienzo, G. Priest, G. Crawford, and T. Walsh (2005): Progress in NTHMP hazard assessment. *Nat. Hazards*, 35(1), *Special Issue, U.S. National Tsunami Hazard Mitigation Program*, 89–110.

48. Gregg, Jacob L., Delsa M. Anderl, Daniel K. Kimura: Improving the precision of otolith-based age estimates for Greenland turbot, *Reinhardtius hippoglossoides*, found in Alaskan waters. *Fishery Bulletin*. Submitted.

49. Gnanadesikan, A., J. P. Dunne, R. M. Key, K. Matsumoto, J. L. Sarmiento, R. D. Slater, and P. S. Swathi, Oceanic ventilation and biogeochemical cycling: Understanding the physical mechanisms that produce realistic distributions of tracers and productivity, *Global Biogeochemical Cycles*, **18**, GB4010m diuL10.1029/2003GB002097, 2004.

50. Hakkinen, S., and P.B. Rhines: Decline of the North Atlantic subpolar circulation in the 1990s. *Science*, 304, pp 555-559.

51. Hamlet, A. F., and D. P. Lettenmaier. (In review). Efficient methods for producing temporally and topographically corrected daily climatological data sets for the continental U.S.. Submitted to the *Journal of Hydrometeorology.*

52. Hamlet, A. F., and D. P. Lettenmaier. 2005. Production of temporally consistent gridded precipitation and temperature fields for the continental U.S.. *Journal of Hydrometeorology* 6(3):330-336.

53. Hamlet, A.F., P.W. Mote, M.P.Clark, D. P. Lettenmaier: 20th Century trends in runoff, evaporation, and soil moisture in the western U.S. *Journal of Climate*, submitted.

54. Hamlet, A. F., P. W. Mote, A. K. Snover, and E. L. Miles. (In review). Climate, water cycles, and water resources management in the Pacific Northwest. Chapter 6 in E.L. Miles, A. K. Snover and The Climate Impacts Group, *Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest*, Cambridge, Massachusetts: MIT Press.

55. Hamlet, A. F., P. W. Mote, M. Clark, and D. P. Lettenmaier. (In press). Effects of temperature and precipitation variability on snowpack trends in the western U.S.. To appear in *Journal of Climate*.

56. Hessl, A. E., C Milesi, D. L. Peterson, M. White, and R.E. Keane. (In press). *Ecophysiological parameters for Pacific Northwest trees*. To appear as a USDA Forest Service General Technical Report, Pacific Northwest Research Station, Portland, Oregon.

57. Heimann, M., and E. Maier-Reimer, On the relations between the oceanic uptake of CO_2 and its carbon isotopes, *Global Biogeochem. Cycles*, *10*, 89-110, 1996.

58. Hessl, A. E., D. McKenzie, and R. Schellhaas. 2004. Drought and Pacific Decadal Oscillation linked to fire occurrence in the inland Pacific Northwest. *Ecological Applications* 14(2): 425-442.

59. Hood, R.R., E.A. Laws, J.K. Moore, R. Armstrong, N. Bates, C. Brown, C. Carlson, F. Chai, S. Doney, H. Ducklow, P. Falkowski, R.A. Feely, M. Friedrichs, M. Landry, D. Nelson, T. Richardson, B. Salihoglu, M. Schartau, and J. Wiggert (2004): Functional group modeling: Progress, challenges, and prospects. *Deep-Sea Res. Pt. II* [Submitted].

60. Huber, J.A., D.A. Butterfield, and J.A. Baross: Diversity and distribution of subseafloor Thermococcales populations at an active deep-sea volcano in the Northeast Pacific Ocean. *Applied and Environmental Microbiology,* submitted.

61. Huber, J.A., H. P.Johnson, D. A. Butterfield, J. A. Baross:Microbial Life in 3.5 Ma Ocean Crust. *Applied and Environmental Microbiology,* submitted.

62. Huber, J.A., H.P. Johnson, D.A. Butterfield, and J.A. Baross: Microbial life in ridge flank crustal fluids. *Applied and Environmental Microbiology,* submitted.

63. Huebert, B.J., B.W. Blomquist, J.E. Hare, C.W. Fairall, J.E. Johnson, and T.S. Bates**:** (2004) Measurement of the sea-air DMS flux and transfer velocity using eddy correlation, *Geophys. Res. Lett.,* 31, L23113, doi:10.1029/2004GL021567.

64. Huppert, D., J. Kaje, A.F. Hamlet, E.L. Miles, and A.K. Snover: Applications of climate forecasts in natural resources management: Implications for industry. *The Climate Report*, 3(2), 12-22.

65. Huppert, D., J. H. Kaje, A. F. Hamlet, E. L. Miles, and A. K. Snover. (In review). Using climate forecasts in natural resource management. Chapter 10 in E.L. Miles, A. K. Snover and The Climate Impacts Group, *Rhythms of Change: An Integrated Assessment of Climate Impacts on the Pacific Northwest*, Cambridge, Massachusetts: MIT Press.

66. Inoue, H.Y., R.A. Feely, M. Ishii, T. Kawano, A. Murata, and R. Wanninkhof (2004): Long-term trend of the partial pressure of CO2 in surface waters and sea-air CO2 flux in the equatorial Pacific. In Global Climate Change and Response of Carbon Cycle in the Equatorial Pacific and Indian Oceans and Adjacent Landmasses, H. Kawahata (ed.), *Elsevier Oceanography Series*, Elsevier, Amsterdam [In review].

67. Ishida, Y., S. Ito, M. Kaeriyama, S. McKinnell and K. Nagasawa. 1993. Recent changes in age and size of chum salmon (Oncorhynchus keta) in the North Pacific Ocean and possible causes. Can. J. Fish. Aquat. Sci. 50:290-295.

68. Ito, T., and M.J. Follows: Preformed phosphate, soft tissue pump and atmospheric CO2. *Journal of Marine Research.* Submitted.

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Appendix 12

Most Cited JISAO Publications

Based on data from the ISI Web of Science. Publications within categories are listed in chronological order. The earliest listings are for the year 1998. All publications listed here have at least 20 citations.

CLIMATE DYNAMICS, GENERAL

Barsugli JJ, Battisti DS**.** The basic effects of atmosphere-ocean thermal coupling on midlatitude variability**,** JOURNAL OF THE ATMOSPHERIC SCIENCES 55 (4): 477-493 FEB 15 1998

Times Cited: 108

Bretherton CS, Widmann M, Dymnikov VP, et al. The effective number of spatial degrees of freedom of a time-varying field. JOURNAL OF CLIMATE 12 (7): 1990-2009 JUL 1999

Times Cited: 27

Lilly JM, Rhines PB, Visbeck M, et al. Observing deep convection in the Labrador sea during winter 1994/95. JOURNAL OF PHYSICAL OCEANOGRAPHY 29 (8): 2065-2098 Part 2 AUG 1999

Times Cited: 40

Bretherton CS, Battisti DS**.** An interpretation of the results from atmospheric general circulation models forced by the time history of the observed sea surface temperature distribution GEOPHYSICAL RESEARCH LETTERS 27 (6): 767-770 MAR 15 2000

Times Cited: 53

DeWeaver E, Nigam S. Zonal-eddy dynamics of the North Atlantic oscillation JOURNAL OF CLIMATE 13 (22): 3893-3914 NOV 15 2000 **Times Cited:** 24

Yin JH, Battisti DS**.** The importance of tropical sea surface temperature patterns in simulations of last glacial maximum climate**.** JOURNAL OF CLIMATE 14 (4): 565-581 2001

Times Cited: 26

ENSO

Wallace JM, Rasmusson EM, Mitchell TP, et al.

The structure and evolution of ENSO-related climate variability in the tropical Pacific: Lessons from TOGA . JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS 103 (C7): 14241-14259 JUN 29 1998

Times Cited: 105

McPhaden MJ. Climate oscillations - Genesis and evolution of the 1997-98 El Nino

SCIENCE 283 (5404): 950-954 FEB 12 1999

Times Cited: 292

Meinen CS, McPhaden MJ. Observations of warm water volume changes in the equatorial Pacific and their relationship to El Nino and La Nina**/** JOURNAL OF CLIMATE 13 (20): 3551-3559 OCT 15 2000

Times Cited: 36

Thompson CJ, Battisti DS A linear stochastic dynamical model of ENSO. Part I: Model development. JOURNAL OF CLIMATE 13 (15): 2818-2832 AUG 1 2000

Times Cited: 22

Thompson CJ, Battisti DS. A linear stochastic dynamical model of ENSO. Part II: Analysis. JOURNAL OF CLIMATE 14 (4): 445-466 2001

Times Cited: 21

Overland JE, Bond NA, Adams JM. North Pacific atmospheric and SST anomalies in 1997: Links to ENSO? FISHERIES OCEANOGRAPHY 10 (1): 69-80 MAR 2001

Times Cited: 25

INTERDECADAL CLIMATE VARIAILITY

Mantua NJ, Hare SR, Zhang Y, et al. A Pacific interdecadal climate oscillation with impacts on salmon production. BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY 78 (6): 1069-1079 JUN 1997

Times Cited: 657

Overland JE, Adams JM, Bond NA. Decadal variability of the Aleutian low and its relation to high-latitude circulation. JOURNAL OF CLIMATE 12 (5): 1542-1548 Part 2 MAY 1999

Times Cited: 61

Garreaud RD, Battisti DS. Interannual (ENSO) and interdecadal (ENSO-like) variability in the Southern Hemisphere tropospheric circulation. JOURNAL OF CLIMATE 12 (7): 2113-2123 JUL 1999

Times Cited: 76

Hare SR, Mantua NJ. Empirical evidence for North Pacific regime shifts in 1977 and 1989. PROGRESS IN OCEANOGRAPHY 47 (2-4): 103-145 2000

Times Cited: 168

McPhaden MJ, Zhang DX. Slowdown of the meridional overturning circulation in the upper Pacific Ocean. NATURE 415 (6872): 603-608 FEB 7 2002

Times Cited: 43

Mantua NJ, Hare SR. The Pacific decadal oscillation JOURNAL OF OCEANOGRAPHY 58 (1): 35-44 FEB 2002

Times Cited: 54

ARCTIC CLIMATE

Rigor IG, Wallace JM, Colony RL Response of sea ice to the Arctic oscillation

JOURNAL OF CLIMATE 15 (18): 2648-2663 SEP 2002

Times Cited: 49

CLIMATE IMPACTS ON MARINE ECOSYSTEMS

Hare SR, Mantua NJ, Francis RC. Inverse production regimes: Alaska and West Coast Pacific salmon. FISHERIES 24 (1): 6-14 JAN 1999

Times Cited: 75

Stabeno PJ, Bond NA, Kachel NB, et al.

On the temporal variability of the physical environment over the south-eastern Bering Sea. FISHERIES OCEANOGRAPHY 10 (1): 81-98 MAR 2001

Times Cited: 44

CLIMATE IMPACTS ON WATER RESOURCES

Widmann M, Bretherton CS. Validation of mesoscale precipitation in the NCEP reanalysis using a new gridcell dataset for the northwestern United States

JOURNAL OF CLIMATE 13 (11): 1936-1950 JUN 1 2000

Times Cited: 24

Nijssen B, Schnur R, Lettenmaier DP**.** Global retrospective estimation of soil moisture using the variable infiltration capacity land surface model, 1980-93**.** JOURNAL OF CLIMATE 14 (8): 1790-1808 2001

Times Cited: 26

Nijssen B, O'Donnell GM**,** Lettenmaier DP, et al./ Predicting the discharge of global rivers. JOURNAL OF CLIMATE 14 (15): 3307-3323 2001

Times Cited: 31

OCEAN CARBON

Sabine CL, Key RM, Johnson KM, et al. Anthropogenic CO2 inventory of the Indian Ocean. GLOBAL BIOGEOCHEMICAL CYCLES 13 (1): 179-198 MAR 1999

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Feely RA, Wanninkhof R, Takahashi T, et al.. Influence of El Nino on the equatorial Pacific contribution to atmospheric CO2 accumulation. NATURE 398 (6728): 597-601 APR 15 1999

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Takahashi T, Sutherland SC, Sweeney C... Feely, RA and C. SabineGlobal sea-air CO2 flux based on climatological surface ocean pCO(2), and seasonal biological and temperature effects. DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY 49 (9-10): 1601-1622 2002

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Feely RA, Boutin J, Cosca CE, et al.

Seasonal and interannual variability of CO2 in the equatorial Pacific. DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY 49 (13-14): 2443-2469 2002

Times Cited: 22

Bates TS, Kapustin VN, Quinn PK, et al. Processes controlling the distribution of aerosol particles in the lower marine boundary layer during the First Aerosol Characterization Experiment (ACE 1) JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 103 (D13): 16369-16383 JUL 20 1998

Times Cited: 56

Anderson TL, Covert DS, Wheeler JD, et al. Aerosol backscatter fraction and single scattering albedo: Measured values and uncertainties at a coastal station in the Pacific Northwest. JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 104 (D21): 26793-26807 NOV 20 1999

Times Cited: 40

Quinn PK, Bates TS, Coffman DJ, et al.

A comparison of aerosol chemical and optical properties from the 1st and 2nd Aerosol Characterization Experiments. TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY 52 (2): 239-257 APR 2000

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Swietlicki E, Zhou JC, Covert DS, et al. Hygroscopic properties of aerosol particles in the northeastern Atlantic during ACE-2 TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY 52 (2): 201-227 APR 2000

Times Cited: 46

Anderson TL, Masonis SJ, Covert DS, et al.. Variability of aerosol optical properties derived from in situ aircraft measurements during ACE-Asia . JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 108 (D23): Art. No. 8647 AUG 19 2003

Times Cited: 22

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